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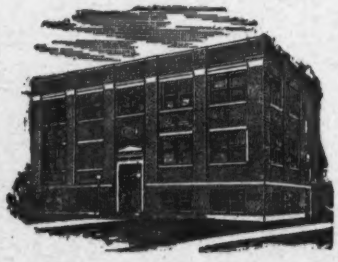

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A GENERAL METHOD OF REPAIRING LOSS OF BONY SUBSTANCE AND OF RECONSTRUCTING BONES BY OSTEOPERIOSTEAL GRAFTS TAKEN FROM THE TIBIA

273 OBSERVATIONS

BY HENRI DELANGENIÈRE, LE MANS, FRANCE, AND PHILIP LEWIN,[1] M.D., CHICAGO

A GENERAL method of repairing loss of bony substance and of reconstructing bones by osteoperiosteal grafts consists not only in grafting bone and periosteum but also in transplanting into the defect all elements of a callus which subsequently will be converted into new bone. The method is applicable in the treatment of pseudarthrosis, in effecting the obliteration of a bony cavity or trephine opening, in rebuilding bones partially or even completely, or in producing a strong arthrodesis. The grafts are usually obtained by removing from the tibia thin layers of bone with the periosteum. The grafts may be taken from any bone provided the two layers of periosteum and bone be used, but the internal surface of the tibia is best because of its large size and because it is easily obtained. (If a large amount of bone is to be replaced, both tibiæ may be used.) The periosteum of the tibia is particularly vascular, and therefore well adapted for easy grafting and secondary rapid vascularization of the bony layer, so that all elements of a callus are supplied, namely, living periosteum and bone, the latter being indispensable in the production of new bone.

It is not the purpose of this paper to discuss the question as to whether new bone is secreted by the periosteum alone, or if it is produced by osseous transformation of connective-tissue cells or even of blood clot. Suffice to say, one can be certain that a layer of bone with its periosteum produces new bone, and that this bone gradually grows and replaces lost bone, and assumes the shape of the bone to be reconstructed. Figure 3, shows a large defect of the tibia filled in by a unilateral osteoperiosteal graft made three and a half years ago. A large, heavy callus nearly as large as the tibia, and taking the shape of that bone, is seen.

The osteoperiosteal graft need not necessarily be in contact with osseous tissue, but can be kept alive and growing when transplanted into soft tissues beneath the skin of the forearm, for example, as the author has done in 2 cases in preparing the skeleton of the nose for an Italian graft.

The graft is taken from the internal surface of the tibia using a single bevel engraver's chisel, and a hammer or mallet. A long incision is made through the skin over the middle of the internal surface of the tibia, without cutting the periosteum. The latter is

[1] It was my good fortune while on duty as camp orthopedic surgeon, American Embarkation Center, Le Mans, Sarthe, France, to see Lieutenant Colonel Henri Delangenière, chief surgeon of the French 4th Region, perform his operation many times, and to be his first assistant in several cases. When the term "author" is used H. Delangenière is meant. —Philip Lewin, Major, M. R. C., U. S. A.

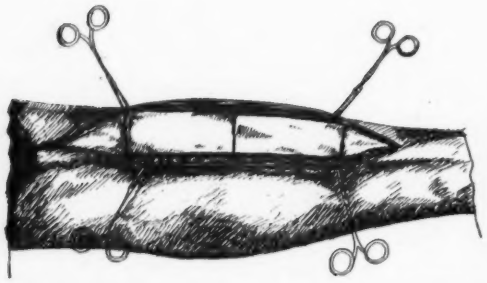

Fig. 1. The internal surface of the tibia exposed and grafts outlined, one below the other.

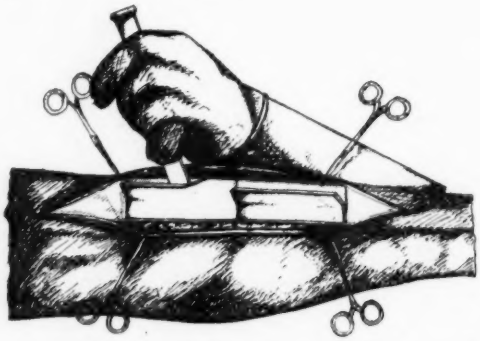

Fig. 2. Removing the graft by means of the chisel. The graft curls up as it is being removed.

exposed thoroughly and the grafts are outlined with a scalpel (Fig. 1). The size of the grafts is determined by the defect to be covered. Following the outline, the graft is removed with a chisel. The bevel is kept high and the cutting edge firmly against the bone. By varying the inclination, one obtains the proper thickness which is approximately that of a ten-cent silver coin. When the graft is removed it is placed in a compress and immediately transplanted into the wound of reception which has been thoroughly prepared previously.

General considerations, which apply to all grafts and to which strict adherence is necessary, are as follows:

1. Most strict asepsis is required. Slight suppuration will not prevent the graft from "taking," but will cause delay. Infection will often cause the elimination of the graft.

2. Antiseptics should not be used because they always reduce the vitality of the graft.

3. Bones to be grafted must be entirely free from osteitis. The skin must be healthy and sufficient in amount and elasticity easily to close the wound.

4. It is necessary that both surfaces of the graft come in contact with living tissues so that there will be no dead spaces. The extremities of the graft must be in contact with the ends of the bone to be repaired.

5. The graft should be held in place by means of catgut sutures through muscles. All dead spaces must be obliterated by this means. Ligatures, sutures, plates, etc., are always harmful to the vitality of the grafts. Quite exceptionally, wire will be found indispensable.

The method is best suited to the following types of cases:

Cranioplasty. The wound must be completely healed and the skin in sufficiently good condition to re-cover the opening without traction. One must guard against latent infection in the wound and delay operation long enough to be sure that perfect healing has taken place; the least discharge or the smallest fistula necessitates postponing operation. It is also necessary, if the patient has cerebral trouble, to determine by spinal puncture that there is no reaction on the part of the central nervous system.

When it has been determined that the patient is in suitable condition for operation, the orifice to be bridged is uncovered at the site of existing scars, which should be removed at the same time in order to obtain primary union. Flaps are turned back and the orifice of the skull is well freed by a periosteal elevator, and the periosteum of the skull is lifted up all around the opening for a space of 2 or 3 centimeters, in order to permit of the easy introduction of the graft. Then the periosteum of the skull is lifted up and the grafts introduced one after the other under the periosteum, carefully placing the bony, or secreting surface, inward. The grafts are placed next to each other like the boards of the floor so that they cover the entire

opening and extend beyond, at least 1 centimeter, in every direction. The skin is then folded back and sutured with interrupted silk-worm, as is done in all autoplasties. Drainage is not necessary unless one fears a hæmatoma, when it is desirable to drain for 48 hours.

If, for a clinical reason of any kind, one fears irritation of the meninges by the production of bone from the grafts, it is necessary to return to the author's original method, placing the smooth periosteal surface next to the brain. In every case one must shape the grafts by means of forceps, before putting them in place so that they will assume the exact form of the skull to be repaired.

Pseudarthroses of the maxilla with or without loss of bony substance. Here the co-operation of the specialist in maxillofacial prostheses is indispensable. It is he who prepares the patient by treatment of the mouth and bad teeth, and who prepares beforehand the apparatus which will hold the jaws together. This apparatus consists of two gutters held together by silver wire. Before operating, the wound must be completely cicatrized and all fear of suppuration eliminated. It is often necessary to perform one or two preparatory operations to be sure that the skin is sufficiently supple and viable to cover grafts completely. The wound is opened at the site of the scar and the ends of the bone exposed by means of a periosteal elevator, taking great care not to penetrate into the mouth, which accident is guarded against by the introduction into the mouth of an assistant's finger. When the ends are denuded as far as possible, the maxilla is reduced the required distance and the grafts are placed one in front and one behind or one gutter below, overlapping the bony ends 1 or 2 centimeters on all sides to prevent the formation of a secondary pseudarthrosis at the level of the ends of the grafts. In rebuilding the angle of the jaw one places two grafts in the angle. The wound is well padded by means of the soft parts to prevent a dead space and to retain the grafts in their place. The skin is sutured as in all autoplasties. Drainage is useless; in fact, may be very dangerous because of the nature of the site of the wound. Nevertheless it is necessary to drain if hæmostasis is imperfect or a hæmatoma is likely to form.

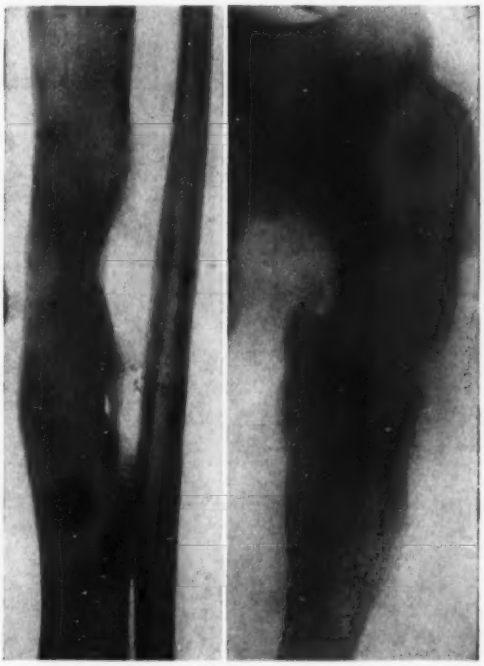

Fig. 3 (at left). Large loss of bony substance of the tibia replaced by unilateral osteoperiosteal graft inserted three and one-half years ago. Note the large, heavy callus nearly as large as the tibia, and assuming the shape of that bone.

Fig. 4. Pseudarthrosis of the humerus with loss of bony substance cured in 3 months by osteoperiosteal graft.

The operation just described is applicable to the ordinary cases of pseudarthrosis of the horizontal portion of the maxilla. It must be modified for the middle part of the bone and for the angle. In the middle it is not possible to secure in good position a posterior graft, so one must simply place a long anterior graft under the periosteum which has been lifted up on each side as a tunnel so that the graft does not become displaced downward by the upper muscles of the neck. At the angle, grafts must be placed vertically in a line with the vertical portion of the maxilla, and in contact with that vertical part. One or two other grafts are then placed on the horizontal part of the maxilla and the three

Fig. 5 (at left). June 5, 1919. Before grafting. Showing loss of bony substance of tibia.
Fig. 6. Same as Figure 5, November 25, 1919, five and one-half months after grafting. Not yet quite solid.

Fig. 7 (at left). Ulna before operation.
Fig. 8. Same as Figure 7, after grafting. Solid union

or four grafts are joined together and fastened with catgut passed through all the layers.

Pseudarthroses of the long bones with or without loss of bony substance. The same rule applies as in repair of the maxilla. Simple pseudarthroses are exposed, bony ends denuded, cicatricial tissue carefully excised, and the grafts placed lengthwise all around the denuded ends.

For loss of substance it is necessary thoroughly to denude the bony extremities, to put them in good position, and to place two grafts lengthwise of the bone, going beyond the ends for a distance of 2 or 3 centimeters so that each end shall be overlapped by the two grafts. The secreting surfaces are applied next to the denuded bone. When it is possible, one graft should be placed inside and one outside. In the free space between the two bony ends the secreting surfaces of the graft face each other. The muscular layer is sutured over the grafts with catgut, in order to prevent a dead space, and the skin is closed. During the operation the best position of the limb is obtained, and in this position it is immobilized in a circular cast with windows. In this way the bony ends are held in place during the formation of the callus and regeneration of bone.

A few modifications for specific cases are as follows:

Femur. When there is a gap of more than 5 centimeters, the ends should be held by means of wire and the grafts placed around them. The wire should be removed at the end of a month and the cast should be changed.

Humerus. The same rule applies as for the femur; a wire can be passed through the bony ends to hold them at the proper distance and to prevent displacement. The cast is applied and must include the chest and arm. Roentgenograms should be made to assure proper position of the fragments. (Fig. 4.)

Tibia and fibula. The fibula may be disregarded. It is necessary to repair the tibia only. For the tibia alone three grafts are necessary; one between the two ends of the bone, one behind and one in front (Figs. 5 and 6).

Ulna and radius. Wire may be used for the radius. Two grafts are required for either

Fig. 9 (at left). Radius before operation.
Fig. 10. Radius after grafting.

Fig. 11 (at left). Flail shoulder before operation, August 17, 1919.
Fig. 12. Same as Figure 11, November 22, 1919. 3 months after grafting. Very solid. Wire still in place.

bone (Figs. 7, 8, 9, and 10). For the ulna alone two grafts are necessary but no wire (Fig. 8). For the radius alone two grafts are necessary but no wire (Figs. 9 and 10).

Obliteration of bony cavities. The bony cavity must be well sterilized and thoroughly curetted before the grafts are placed in the cavity. The grafts are placed one on top of the other. They grow and fill up the cavity with new bone. It is absolutely necessary that there be sufficient viable skin to cover the grafts completely.

Large facial and other grafts. It is possible to restore missing parts of the face, nose, walls of sinuses, malar bone, superciliary ridge, and orbital fossa. The grafts must be molded and trimmed to take the form of the bone to be replaced. In order to obtain good results, the most important point is to secure a point of bony contact for each graft. It is also necessary that the tissues be well padded and secured by catgut and a normal skin, which has been prepared in advance for an autoplasty.

Flail shoulder. In cases of flail shoulder, grafts are used to produce a very strong and heavy callus, which can firmly unite the end of the humerus, which has been well denuded, to the glenoid cavity, from which the cartilage has been removed. This arthrodesis will result in a very useful shoulder if the arm is held in abduction in a spica cast over the chest and arm during the formation of callus. A wire is necessary to hold the bones in good position. It must be removed when the callus is ossified, that is, about 3 months after operation (Figs. 11 and 12).

Flail knee. In treating flail knee the same rules apply as for flail shoulder. A wire is used to keep the end of the femur against the end of the tibia after all articular cartilage has been removed. One graft is placed on each side, bridging the gap, and overlapping both bones, which can be easily accomplished by bending each graft in the middle.

Flail elbow. In flail elbow, the bony ends are well denuded; a wire is passed through the humerus and the ulna to hold them together. Grafts are then placed completely around the denuded bones, and the arm, held in good position, is placed in a cast (Figs. 13 and 14). (Before operating, the elbow should be flexed at 70° to 90°.)

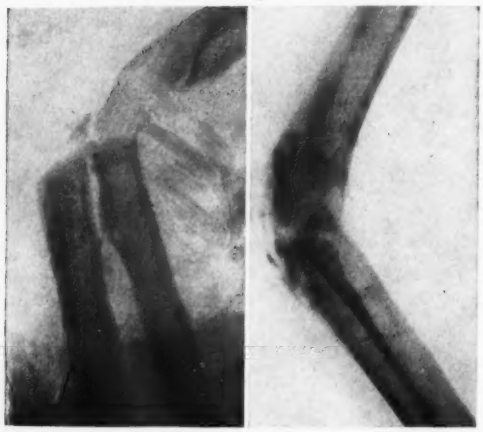

Fig. 13 (at left). Flail elbow, before operation.
Fig. 14. Same as Figure 13, 6 months after operation. Elbow quite solid. Wire has been removed.

Flail wrist. In a case of flail wrist treated by the author, the radius and ulna had been excised for a distance of about 4 centimeters above the wrist-joint. Four grafts, each of the same length as the width of the forearm, were placed, one above another, filling in the gap. The skin was sutured and the wrist immobilized in a plaster-of-Paris cast. No wire was used.

Evolution of the graft. The evolution of the graft is easily followed by the X-ray which shows the bone growing more and more dense and thick. As thickening becomes more marked in the X-ray, one recognizes clinically, by palpation, the growth and hardening just as in a fracture callus. Therefore, it is evident that the osteoperiosteal graft acts not only as a graft but that it secretes bone, thus uniting the fracture ends and finally producing callus, which rebuilds bone and reestablishes continuity of function.

The graft may grow too abundantly in very young people. This result is rare and of no importance except in reconstructing the face, especially the nose. Because of this possible excessive growth, the author at first placed grafts in cranioplasty operations with the periosteal surface next to the brain. Later, however, he found that this fear was exaggerated, and that the grafts could be placed with the bony side next to the brain.

Absorption of the grafts has never been observed. Where the graft has been eliminated the result will certainly not be the best but it will not be worthless; the bone will be thinner and less dense, but bone will form in the majority of cases, provided the expulsion of the graft did not carry away the entire bony layer.

Wound of the tibia. The wound of the tibia is insignificant. It heals primarily. It is well to drain in order to prevent a hæmatoma. No grave complications have ever occurred. At times a hæmatoma may develop; at times the discharge of small spicules of bone occurs. Generally the wound has healed at the end of the eighth day.

RESULTS

The results of the first operations were, indeed, very satisfactory, but the technique has been perfected so that it can now be stated that osteoperiosteal grafting is nearly always followed by reconstruction of the bone. This report is based on 273 observations of osteoperiosteal grafts, as enumerated below, and covers the use of the method under normal and abnormal conditions. The following results were obtained:

Cranioplasties, 104 cases with 99 very good or good results, 3 partial repairs and 2 failures following the elimination of the grafts. However, these two cases were operated upon again with good results.

Loss of bony substance of the inferior maxilla, 53 cases with 43 good results, 4 partial successes, and 6 bad results which will necessitate secondary operations.

Wounds of the femur, 3 cases with 1 very good result, 1 unknown result, and 1 late death in the case of an intractable alcoholic who died from chronic septicæmia 3 months after operation.

Wounds of the tibia, 15 cases with 13 very good results, and 2 partial cures.

Wounds of the fibula, 2 cases with 2 good results.

Wounds of the humerus, 15 cases with 13 good results, and 2 partial cures.

Wounds of the ulna, 23 cases with 19 good results, 3 unknown, and 1 failure due to the entire elimination of the graft.

Wounds of both ulna and radius, 3 cases with 2 good results, and 1 followed by a new pseudarthrosis which was cured by a second operation.

Wounds of the radius, 12 cases with 11 good results, and 1 incomplete cure.

Obliteration of bony cavities, 9 cases with 9 cures.

Repair the face, 21 cases with 19 good results, and 2 incomplete cures.

Flail knees, 3 cases with 3 good results.

Flail shoulders, 3 cases with 3 good results.

Flail elbows, 4 cases with 4 satisfactory results.

Flail wrist, 1 case with a good result.

Radical cure of hernia, 1 case with a good result.

Relapsed luxation of the hip, 1 case with a good result.

THE OPERATIVE TREATMENT OF VESICOVAGINAL FISTULÆ[1]

By E. S. JUDD, M.D., F.A.C.S., Rochester, Minnesota
From the Mayo Clinic

FISTULÆ between the bladder and the vagina are the result of difficult parturition, or some operative procedure, most often the extirpation of the uterus for cancer. In the early days most of the cases of fistula that were under observation were the result of trauma at the time of childbirth. It was in the treatment of such cases that Sims developed the first accurate operative technique for their repair. In later years, however, several factors have arisen to change conditions materially. In the first place, better obstetric management has greatly reduced the number of fistulæ which occur as the result of difficult labor, but there has been a great general wave for the radical extirpation of cancer both by operative procedure and by cautery and large doses of radium. While the ultimate results of these operations and treatment warrant the procedure, they very greatly increase the number of cases of vesicovaginal fistula. Sampson, in 1904, reported 19 cases following 158 hysterectomies for carcinoma of the cervix, while a review of the cases in which we have operated since 1908 shows that 61 per cent have resulted from some operative procedure for the removal of tumors of the uterus, and only 39 per cent followed childbirth. These percentages undoubtedly would be different in a strictly obstetric and gynecologic clinic, but they indicate the cause of the fistulæ generally seen.

The occasional satisfactory result of the treatment of a carcinoma of the cervix which is extensive and involves the vaginal mucosa, undoubtedly warrants the continuance of treatment in such cases. The apparent complete disappearance of a large cauliflower cancer of the cervix after a few treatments with radium is most striking, but these treatments should not be undertaken without considering the fact that a fistula from the bladder may result from the use of radium alone as well as from operation or cautery. If the malignancy is eradicated so that the fistula may be repaired satisfactorily the operation is certainly justified, but if the patient is left without control of the urine and with malignancy persisting in the edges of the fistula or evident in other places, the treatment cannot be justified. For this reason the extent of involvement must be studied carefully to make sure that the patient has some chance of relief before the additional risk is taken. Radium has been a great help in the treatment of cancer of the cervix and ordinarily it can be used without the danger of injury to the bladder, although there are 5 cases in our series in which the fistulæ followed the use of radium alone.

The scar resulting from the cautery or radium renders the technique of the operation much more difficult than in the cases which follow childbirth. The scar from the

[1] Presented before the Western Surgical Society, Kansas City, Missouri, December, 1919.

TABLE I. — TYPE OF URINARY FISTULÆ OPERATED ON FROM JANUARY, 1908, TO SEPTEMBER, 1919

Vesicovaginal	67
Vesico-ureterovaginal	6
Vesico-uretero-uterine	1
Vesico-uterovaginal	5
Vesico-urethrovaginal	3
Total	82
Age of youngest patient	19 years
Age of oldest patient	64 years

TABLE II.— CAUSES OF FISTULÆ

	Cases
Childbirth	32 (39 per cent)
Operation	50 (61 per cent)
Hysterectomy	31 (13 in our clinic)
Percy cautery (no hysterectomy)	4 (2 in our clinic)
Excision of cervical stump	3 (0 in our clinic)
Percy cautery and radium for recurring cancer (previous hysterectomy)	3 (2 in our clinic)
Amputation of cervix	2 (0 in our clinic)
Litholapaxy through urethra	2 (0 in our clinic)
Puncture drainage of bladder for cystitis	3 (0 in our clinic)
Abscess drained through vagina	2 (0 in our clinic)
Total	50 17
Shortest time between occurrence and repair	3 weeks
Longest time between occurrence and repair	24 years

use of the cautery is thick and firm, and it is very troublesome to free the tissues so that the flaps may be approximated and sutured. The flaps tear readily so that care must be taken in forcing the needle through them. The scar resulting from the trauma of parturition is much smaller and the tissues are much more pliable and easier to suture.

The apparent ease with which vesicovaginal fistulæ may be closed is deceiving sometimes and, unless definite principles are followed, the results will not be uniformly satisfactory. Too many times, I believe, an attempt is made to close the opening before dissecting the bladder wall well away from the vaginal wall. In some instances it may be possible to close the opening in this manner, but I agree with recent writers on the subject who emphasize the fact that the underlying principle of the technique of the operation is the separation of the wall of the bladder from the wall of the vagina. The condition which keeps the fistula from healing of its own accord is the fact that the mucous membrane of the bladder and vaginal wall have healed together, thus forming a continuous mucous membrane surface from the bladder to the vagina. The first essential in the treatment consists in destroying the communication, and the best manner of accomplishing this is completely to dissect the bladder away from the vagina as is done in the operation for the relief of cystocele. If the mucous membrane of the fistulous tract is not freed so that it can be turned into the bladder on the one side and into the vagina on the other, the communication will almost certainly reform. A review of our cases shows that often several operations have been necessary before the fistula closed permanently. Sixty-eight per cent of our patients had been operated on from one to seven times before coming to the clinic. In most instances these operations had apparently been done well; in others I believe the operator had been deceived into performing an operation by its apparent simplicity. Undoubtedly a certain percentage of these patients require more than one operation, and I believe we are justified in repeatedly attempting to try to close the fistula if the sphincter muscle has not been destroyed. If the urethra and the sphincter muscle are destroyed, there is nothing to be gained in operating to close the fistula as the urine will continue to escape. At times the urethra may be destroyed and the sphincter be intact; in these cases the operation should be performed as the absence of the urethra will not cause any great inconvenience. In other cases the sphincter may be divided or torn by trauma, and there is every likelihood that the sphincter will functionate if it is repaired; therefore operation to close the fistula and repair the sphincter should be done. It seems to me that the operability of these cases depends on whether or not there is a sphincter muscle. Even though it is severed, any number of attempts should be made to repair it before the only other feasible procedure is advised, that is, some plan of diverting the urine to the rectum, thereby leaving it under the control of the rectal sphincter; this may be done if the sphincter of the bladder is completely destroyed. Probably Keen's plan is the best one to adopt in these unfortunate cases, that

is, to make a large communication between the vagina and rectum just above the anal sphincter and then close the vaginal outlet. In Keen's case the woman defæcated and urinated for more than 35 years and menstruated for 11 years by rectum. Peterson collected 41 cases in which this operation was performed with comparative success. In one case only the patient died of a kidney infection and that was some months after the operation; the infection was not believed to be due to the entrance of organisms from the colon to the bladder.

The basis of this review is the 78 cases in which operation was done in our clinic from January, 1908, to September, 1919[1]. In 54 of these cases it was possible to close the fistula at one operation; in 16 two operations were performed, and in 1 six operations failed completely to close the fistula. The fistulous opening in these cases varied from the size of a small pin-point to complete eversion and prolapse of the bladder. Complete prolapse of the bladder into the vagina occurred in 2 cases, one following childbirth in which several operations had formerly been done, and one following combined cautery and radium treatment for cancer of the cervix. In the first case the fistula was repaired successfully, but in the second case the repair was not complete; the entire anterior part of the rectum had been destroyed by the use of the cautery, and it was impossible to keep the field of operation clean.

In 75 cases the fistulous opening was single; in the other 3 cases there was more than one opening. The multiple fistulæ did not offer any more difficulties than the single. A large incision in the vaginal wall included all the openings and converted the operation into a single closure after the openings into the bladder had been separately closed.

The bladder sphincter was involved in 10 cases, but it was destroyed in only 3; it was repaired quite satisfactorily in the 7 cases.

One of the ureters was involved with the vesical fistula in 6 cases. I believe that it is very important to determine the relationship of the ureters whenever it is possible. In a few instances the opening of the ureter was found close to the edge of the fistula and it was possible to turn it into the bladder, or at least avoid injuring it. In several of the cases in which the ureter was involved the suprapubic operation was performed; the ureter was transplanted if it appeared to be in good condition, and the opening of the vesical fistula closed. In one of these cases the ureter was thickened and evidently had been completely occluded for a long time so that it seemed advisable to ligate it.

In all cases in which the suprapubic operation was selected, it was selected for some special reason; it was not employed generally in vesicovaginal cases. The patients on whom the suprapubic operation was performed have all done well, and their convalescence was more favorable than might have been expected. While the suprapubic opera-

[1] I am greatly indebted to Dr. R. G. Andres for his careful study of our case records and the resulting data.

TABLE III.—Operations Elsewhere

Repair attempted before coming to clinic in....	44 cases
13 patients had had 1 operation.	
15 patients had had 2 operations.	
6 patients had had 3 operations.	
4 patients had had 4 operations.	
3 patients had had 5 operations.	
2 patients had had 6 operations.	
1 patient had had 7 operations.	
No previous operation for repair of the fistulæ	38 cases

TABLE IV.

Patients operated on in the clinic.....	78
54 patients had 1 operation.	
16 patients had 2 operations.	
4 patients had 3 operations.	
1 patient had 4 operations.	
2 patients had 5 operations.	
1 patient had 6 operations.	
Inoperable recurring carcinoma of the bladder ruled out, plastic operation in.....	4 cases
The fistulæ varied from a very small opening to complete eversion and prolapse of the bladder.	

TABLE V.—Extent of Involvement

Bladder sphincter.....	10 cases
Bladder sphincter completely destroyed.....	3 cases
Ureter.....	6 cases
Single fistulæ.....	79 cases
Multiple fistulæ.....	3 cases

TABLE VI.—Type of Operation

Plastic closure: Layer suture; dissection of fistulous tract and closure; inversion of edges by tension through meatus.....	69 cases
Suprapubic operation.....	5 cases
Transplantation of the ureter.....	3 cases
Ureter ligated.....	1 case

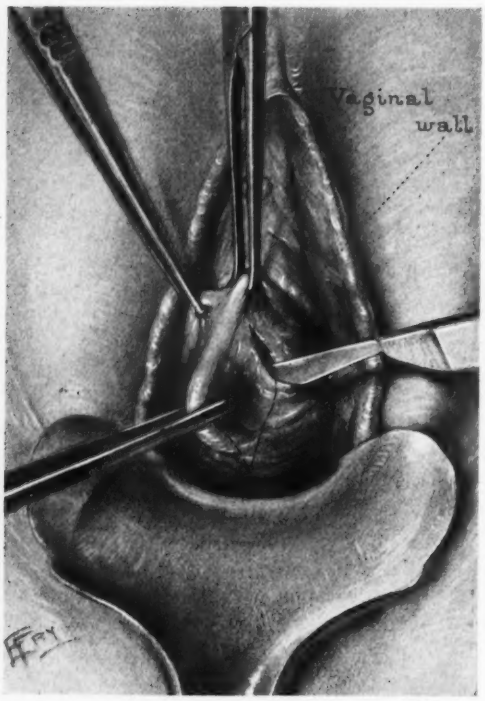

Fig. 1. Dotted line indicating area around fistula to be incised.

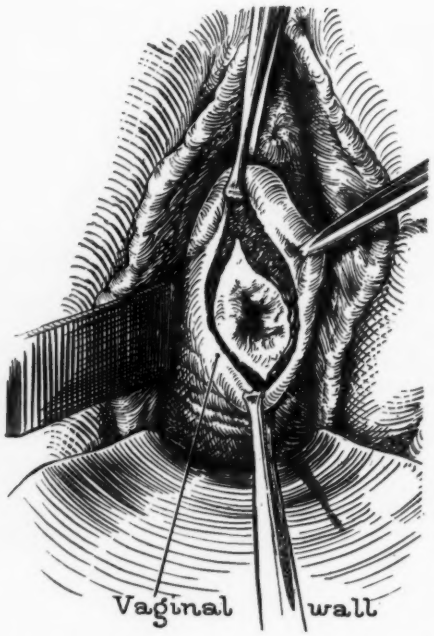

Fig. 2. Incision completed and vaginal wall retracted.

tion offers a good chance for cure, it also offers a greater opportunity for infection, and should not, therefore, be chosen unless especially indicated. Our suprapubic operations were performed extraperitoneally.

Trendelenburg is credited with having performed the first suprapubic operation for vesicovaginal fistula in 1890, and, according to Ward, 27 such operations were reported within the next 14 years. Fewer operations have been reported during the past 15 years, probably on account of the added risk of infection.

Legueu has recently advocated the transperitoneal vesical route for operation in cases of vesicovaginal fistula. One of his 12 patients operated on by this method died. He claims, for this method, wide exposure and every security for healing since in making closure the bladder incision is covered by peritoneum. Such suprapubic operations undoubtedly should be carried out in some of the very bad cases, especially if the ureter and bladder are traumatized. In certain instances the fistulous tract becomes attached to the pubic bone and is thus held in a most inaccessible position, making closure difficult by the vaginal route. In some of these cases the suprapubic operation can be used to advantage.

In most instances cases of vesicovaginal fistula can be dealt with satisfactorily by making plastic closure of the fistulous openings through a vaginal incision. If the opening is small the technique described by C. H. Mayo may be followed, that is, inverting the fistula into the bladder. The inverted fistula is held in the bladder by tension on the purse-string suture which is pulled out through the urethra.

Dr. Crenshaw, of our staff, has closed a number of small vesicovaginal fistulæ by the use of the high frequency current. If the fistula is small it is well worth while to try this method before attempting an operation.

Before any operation is undertaken, an effort must be made to get the tissues in the

Fig. 3. Dissection of the wall of the vagina from the wall of the bladder.

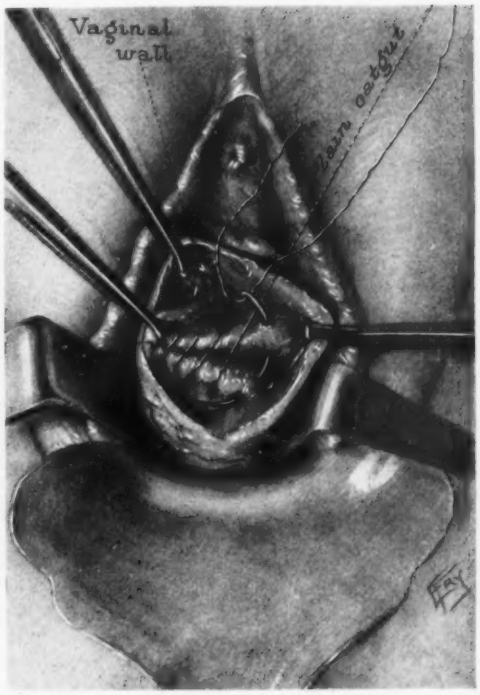

Fig. 4. Suturing the wall of the bladder.

best possible condition for healing. This frequently requires several weeks since often the mucous membrane of the vagina, the labia, and even the skin of the thighs are excoriated and infected, and contain deposits of salts. A cystoscopic examination should always be made in order to determine the position of the ureters, the presence or absence of a sphincter muscle, and whether or not the bladder is completely severed from the urethra. One of the greatest difficulties encountered is trauma to the vesical neck. The vaginal operation certainly should be chosen in all cases of injury near the neck of the bladder, the part difficult to expose by suprapubic incision, so that in such injuries this incision would be distinctly contra-indicated. If the opening in the bladder is high in the vaginal fornix and especially if there is much scar tissue, as there is apt to be following cautery or total hysterectomy, it will be difficult to obtain sufficient exposure by vaginal incision, and in some instances it may seem best to perform the suprapubic operation. The fistula can usually be made accessible, however, so that the operation may be done through the vagina. Very often the perineum is badly torn, and incision into it for exposure is not necessary, but if the incision is necessary it should be made unhesitatingly, and the openings closed at the completion of the operation. One of the chief steps in this procedure is a long incision in the vaginal wall down to the bladder. Usually the incision is begun immediately below the sphincter muscle and extended to and through the fistulous opening, after which the bladder is separated from the vagina for a considerable distance (Fig. 1). I have found it easier to begin this dissection as near the cervix as possible and to bring it forward toward the urethra. Unless this step is thoroughly carried out, the chance for a cure is not good. If the

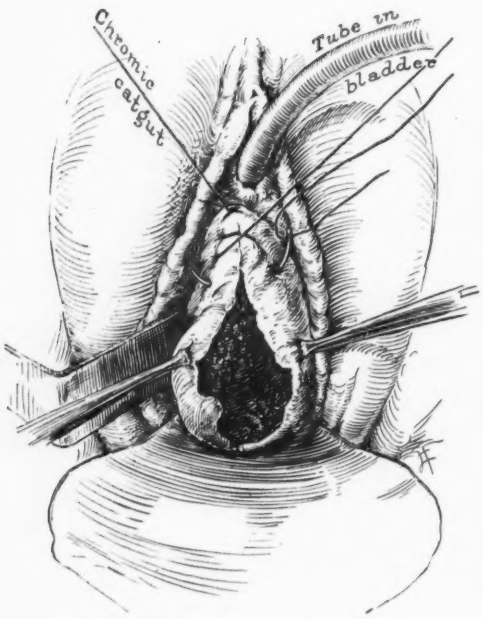

Fig. 5. Suturing the wall of the vagina.

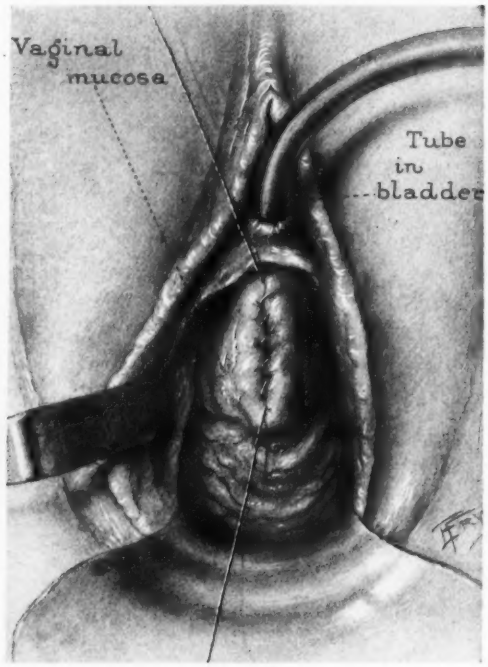

Fig. 6. Closure of the wall of the vagina.

cervix has not been removed, downward traction should be exerted upon it as this helps materially in the exposure (Fig. 2). If the cervix has been removed and the fistula is high in the vagina, it may be best to open the peritoneum widely in order freely to mobilize the bladder and bring the fistula into view. Several years ago Kelly suggested opening the peritoneum and I have followed this method a number of times to great advantage. It must be remembered that loops of intestine are usually caught in this scar and are apt to be injured. This accident happened in one of my operations, but I was able to repair the opening in the intestine without much trouble. Ordinarily I do not believe that it is necessary to open the peritoneum, but in almost inaccessible cases it is helpful. Slight infection may follow, although it was not a complication in my cases. In one case in which I did not open the peritoneum the patient developed a fæcal fistula through the vagina, and I was obliged to repair it by abdominal procedure.

A small curved hæmostat passed through the urethra and into the vagina through the fistula has helped us most to bring the fistulous tract downward into the dissection. The dissection of the bladder should be carried on until the wall is loose and free and until the edges can be easily approximated (Fig. 3). In the cases of extensive injury this is sometimes impossible and it then seems best to close the bladder opening as completely as possible without using tension on the sutures; complete closure can be made later. If too much dissection and tension is employed the circulation to the flaps will be reduced, and sloughing of the tissues will occur. Fortunately many of the tissues may be separated without harm. It is better to perform two or three operations than to carry the procedure too far at one time. The opening in the bladder should be closed with catgut and the edges of the mucous membrane inverted (Fig. 4). The vaginal incision should be closed with chromic catgut and all dead space between

the bladder and vagina obliterated (Figs. 5 and 6). In case the sphincter has been repaired or the urethra sutured back to the bladder it is best to use fine silk sutures in addition to the catgut, being cautious not to penetrate the mucous membrane with the silk.

A retention catheter is left in the bladder for from 8 to 10 days, and great care must be taken to make sure that it drains properly. Patients should be kept quiet for from 12 days to 2 weeks.

There was no mortality in this series of cases, and the ultimate results were very satisfactory in a large percentage. We have recently received information concerning 56 of the 78 patients. Four state that they have derived no benefit from the operation; 6 are considerably improved, although there is still slight incontinence of urine. All the other patients are completely relieved and the bladder function is normal.

In conclusion I wish to emphasize points as follows:

1. Vesicovaginal fistulæ are now more common following operations than following childbirth.

2. All vesicovaginal fistulæ should be considered operable as long as the sphincter muscle of the bladder is intact or can be repaired. If the sphincter has been completely destroyed it will be necessary to consider some other procedure.

3. Suprapubic extraperitoneal operations seem to be indicated if the cystoscopic examination reveals injury to a ureter as well as to the bladder, or it may be indicated if the fistulous tract is adherent to the pubic bone.

4. The plastic vaginal operation consists in completely separating the bladder from the vagina, and closing the two separately and obliterating all dead space.

5. A large percentage of complete and permanent cures follow such operations.

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A CONGENITAL ANOMALY OF THE DUODENUM AND ITS SURGICAL SIGNIFICANCE[1]

By LEONARD FREEMAN, M.D., F.A.C.S., Denver, Colorado

In operating upon the stomach for supposed occlusion of its outlet, especially before the extensive use of the roentgen-ray, surgeons occasionally were puzzled by finding a dilated pylorus and duodenum instead of a stenosis. Considerable time elapsed before it was recognized that partial chronic obstruction of any portion of the intestinal tract might result in "backing-up" of the contents of the bowel upon the stomach, giving rise to stenotic and other gastric symptoms and possibly duodenal ulceration. I am convinced that this important fact is not kept in mind as clearly as it should be, thus leading to the overlooking of conditions that could be corrected if searched for intelligently.

Among a multitude of possible obstructive lesions are those occurring at the duodenojejunal angle. It will be remembered that Lane described a "kink" sometimes existing where the fourth portion of the duodenum appears from beneath the root of the transverse mesocolon to the left of the spine, to merge into the jejunum. The duodenum is here ascending and fixed, owing to the absence of a peritoneal covering; while the jejunum is descending, enveloped in peritoneum, and free, thus giving rise to the normal duodenojejunal angle (Fig. 1).

Occasionally, a peritoneal fold from the colonic mesentery (ligament of Treitz) pulls on the jejunum and increases the normal angulation until it becomes pathologic, the condition being perhaps aggravated by contracting bands. It is obvious that when once recognized the difficulty can be corrected by dividing this fold, which is readily done because of its accessibility.

I wish to describe another form of duodenojejunal kink, depending upon the persistence of an embryonic condition.

It will be recalled that the adult normal duodenum swings in a somewhat angulated loop from the pylorus downward to the right of the spine, passing beneath the hepatic colon to its pelvic side. It then runs directly across the spine, beneath the superior mesenteric vessels and the mesentery of the small intestine and finally ascends obliquely toward the left to join the jejunum at the base of the transverse mesocolon.

During early fœtal life, and in certain lower animals, the entire duodenum is covered by peritoneum and possesses an individual mesentery; but later the terminal three-fourths loses its peritoneum, becomes fixed in fibrous tissue, and attaches itself to the root of the transverse mesocolon, to the left of the median line, at the duodenojejunal angle. This attachment ("duodenal fold") occurs early and is quite constant.

In the anomaly under consideration, the duodenum, after passing beneath the colon, travels, as it were, too far toward the pelvis, thus bringing the transverse portion an unusual distance below the mesocolon. In addition, after passing beneath the colon, it does not become subperitoneal, as it should, but lies free in the abdominal cavity, with a peritoneum and mesentery of its own, as in the fœtal state just mentioned. But in spite of this freedom, the duodenojejunal angle often remains firmly attached on the left to the root of the mesentery of the transverse colon by the duodenal fold, thus suspending the intestine and possibly kinking it at the point of suspension (Fig. 2). A certain amount of twisting of the bowel may contribute to the tendency to obstruction, as may likewise the inclination of the root of the mesentery of the small intestine to push downward the free duodenal loop, especially if filled.

The peculiarity is of course congenital, but we may assume that it can increase with age, because of thickening and contraction of the suspending ligament, until partial obstruction finally appears. This leads to hypertrophy and dilatation of the duodenum, with stagnation of its contents, and eventually to widening of the pylorus and alterations in the stomach.

[1] Read before the Western Surgical Association, Kansas City, December 6, 1919.

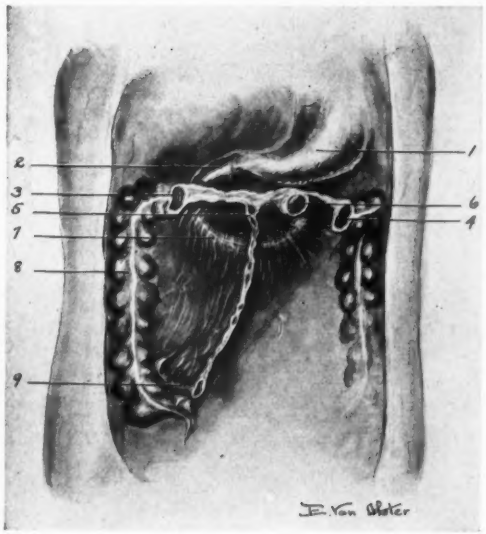

FIG. 1. *1*, stomach; *2* and *7*, duodenum; *3* and *4*, severed ends of transverse colon, removed to show root of mesocolon; *5*, mesentery of small intestine; *6*, duodenojejunal angle; *8*, ascending colon.

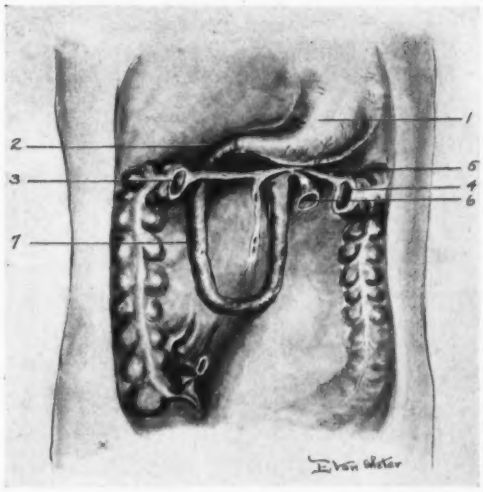

FIG. 2. *1*, stomach; *2*, first portion of duodenum; *3* and *4*, severed ends of transverse colon, removed to show root of mesocolon; *5*, "kink" at duodenojejunal angle; *6*, jejunum; *7*, free duodenal loop (length exaggerated in drawing) passing beneath mesentery of small intestine.

The symptoms so closely resemble those of duodenal ulcer with pyloric obstruction that a correct diagnosis is hard to make without help from the X-ray, and even then certainty is not apt to be obtained short of an exploratory incision. In operating, however, it is important to bear the possibility of the trouble in mind, for "what we don't think of we may not see."

The surgical treatment may be difficult because of certain more or less awkward complications.

1. The lesion is deeply situated, being due to a firm adhesion pulling the gut down to the root of the colonic mesentery, the embarrassment often being further increased by the location of the incision, which is usually to the right of the spine, while the kink is to the left.

2. The inferior mesenteric vein and left colic artery lie just external to the kink and might be injured if care is not exercised. Hence one should cautiously strip the peritoneum bluntly from the surface of the bowel, rather than attempt to divide the ligament with knife or scissors, taking care that the gut is not perforated during the manipulation.

3. The completion of the procedure exposes a raw intestinal surface which may be quite large, and requires attention in order to prevent troublesome adhesions. Sometimes the edges of the torn peritoneum can be so stitched together as to cover the denuded area without compromising the lumen of the bowel; occasionally it may be desirable to use a free omental graft, as I have done in one instance.[1]

Since my attention has been called to this subject I have operated upon six of these duodenal obstructions. In no one of them, in spite of the X-ray, was the diagnosis made previous to the operation, the real trouble being discovered only after a lesion near the pylorus had been excluded.

SUMMARY

Partial occlusion of the duodenum at the duodenojejunal angle, simulating pyloric obstruction, occasionally occurs from the persistence of a condition normally existing in fœtal life. In this, the duodenum, instead of appearing in the abdominal cavity from beneath the transverse mesocolon to the left

[1] Dr. C. U. Collins has short-circuited the obstruction by anastomosing the ascending portion of the duodenal loop to the jejunum, which occasionally may be advisable.

of the spine, as it should, emerges to the right, its transverse and ascending portions possessing a peritoneal covering and mesentery of their own, similarly to the rest of the small intestine, instead of being fixed in fibrous tissue, as is normally the case. At the duodenojejunal angle, however, the bowel is hung up to the root of the colonic mesentery by a firm adhesion (duodenal fold of fœtal life), the "kink" thus produced being intensified by the downward pull of the free duodenal loop. This kink is deeply situated and in freeing it care must be taken not to injure the bowel, the inferior mesenteric vein or the left colic artery. A considerable denudation of the gut may be necessary, which should be covered either by reuniting the peritoneum or by means of a free omental graft.

ENDO-ANEURISMORRHAPHY[1]

I. Statistics of Operation of Endo-Aneurismorrhaphy

II. Personal Experiences and Observations on the Treatment of Arteriovenous Aneurisms by the Intrasaccular Method of Suture with Special Reference to the Transvenous Route[1]

By RUDOLPH MATAS, M.D., LL.D., F.A.C.S., New Orleans

STATISTICS OF OPERATION OF ENDO-ANEURISMORRHAPHY

At different times I have published detailed statistics of the operation of endo-aneurismorrhaphy in all its phases, the first systematic description being given in the *Transactions of the American Surgical Association*, in 1902, which included the first case operated upon by my method, dating back to March 30, 1888. The most complete report was presented before the International Medical Congress, London, August, 1913, in which was included a detailed and classified account of 225 cases. This report was buried in the transactions of the congress and therefore received but little publicity. The list of operations and results up to December 31, 1915, presented at the Muetter Lecture, Philadelphia, increased the number of reported cases available for statistical purposes, to 289. The diversion of professional interests created by the world war suspended the further collection of statistical material. Nevertheless, I have been able to add 28 new cases (chiefly personal and American) from July 1, 1916, to September, 1919, increasing the total list to 317 cases.

It has given me much pleasure to find that the method of intra-aneurismal suture has been found very satisfactory in the treatment of war aneurisms, both arterial and arteriovenous in the cases in which it has been applied. The method has been used by many foreign surgeons in the belligerent armies, who, though applying the intrasaccular suture on the principles which I and my co-workers, have long advocated, have not always given credit to its American, or even its antebellum origin. I regret that in spites of the numerous articles published, a lamentable ignorance is displayed, especially by foreign writers in regard to the underlying principles and simple technique of the methods of intrasaccular suture embraced under the term endo-aneurismorrhaphy. I feel that it is due my many friends and to the contributors to the

Note.—The spelling of the word "endoaneurismorrhaphy" as given in this article is in accordance with the classical orthography of the dictionaries. In revising the proof, Dr. Matas writes that he regards this spelling of the word as archaic and has personally abandoned it in favor of the contracted word "endoaneurismoraphy" which is equally descriptive and faithful to its Greek origin, but much simplified by the elimination of unnecessary consonants in accordance with the rules of the Carnegie Spelling Board.—Editor.

[1] This article is a summary of an original paper read by Dr. Matas before the Southern Surgical Association (in New Orleans, December 16-18, 1919), upon (1) "Personal Experiences and Observations on the Treatment of Arteriovenous Aneurisms by the Intrasaccular Method of Suture, Endo-Aneurismorrhaphy, with special Reference to the Transvenous Route," and (2) a summary of "Statistics of the Operation of Endo-Aneurismorrhaphy," and is a discussion of a paper by Dr. Gaston Torrance on "Femoral Aneurism."

statistics of the operation that some account of the statistical progress be made. To this end a tabulated summary of the unpublished report which I presented at the Muetter Lecture in Philadelphia is given. This report does not include the group of cases which have accumulated since that date and to which I shall briefly refer after reading the table.

The total number of cases of endo-aneurismorrhaphy reported up to December 31, 1915, at the Muetter Lecture, Philadelphia, including the 225 previously reported at the International Medical Congress of London, August 1913, is shown in Table I.

TABLE I

Total cases up to December 31, 1915 289
Eliminating 6 cases—4 fatal inoperable aortic aneurisms and 2 accidental deaths, leaves a total of 283
Deaths ..... 13, or 4.5 per cent
Operative cures and recoveries ..... 270, or 95.4 per cent
Cases of gangrene ..... 12, or 4.2 per cent
Secondary hæmorrhages ..... 6, or 2.1 per cent
Of 289 operations there were of the

	Cases	Per Cent	Deaths	Per Cent	Gangrene	Per Cent
Obliterative type	193	66.8	10	5.3	9	4.6
Restorative type	65	22.5	2	3.0	1	1.5
Reconstructive type	31	10.7	1	3.2	2	6.4

These operations cover all the large surgical arteries, including the abdominal aorta. Fully 86.1 per cent involve the arteries of the lower extremity, including the external iliac; of the popliteal aneurisms there were 154 cases, or 53.2 per cent; of femoral aneurisms, 61 cases, or 21.1 per cent, of the whole. If the popliteal group is selected as one of the most certain tests for all aneurism operations, we find that it has been performed in all the three types of endo-aneurismorrhaphy, 154 times. Of these, 103 were obliterative operations followed by 6 cases of gangrene, or 5.2 per cent; 2 secondary hæmorrhages, or 1.3 per cent; 2 relapses in the reconstructive group or 1.3 per cent, one of which was cured by a secondary obliterative suture. In the 154 popliteal operations there was only one death, or 0.6 per cent mortality, and 8 cases of gangrene, or 5.2 per cent. The total number of failures from all causes, including the 8 cases of gangrene, was 10, or 6.4 per cent. Five cases of gangrene occurred after the obliterative operation, 1 in the restorative group, and 2 in the reconstructive. The total recoveries as to life were 143, or 99.3 per cent, and the total operative successes as to cure of the aneurism with good functional results as to life and limb, 93.6 per cent.

The results obtained by combining all the operations performed on the aneurisms of the lower extremity, including the external iliac, iliofemoral, femoral, popliteal and tibials, were, up to January 1, 1916, in 246 cases, 230 cures and 16 failures, or 6.5 per cent from all causes. Since January 1, 1916, up to September, 1919, the author records 28 additional cases, exclusive of a considerable number of operations performed during the war by foreign surgeons which have not been tabulated. Of these 28 endo-aneurismorrhaphies, 17 were obliterative, 7 restorative, and 4 reconstructive. In these groups are included 7 aneurisms of the neck and upper extremities, 5 femoral, 16 popliteal, with 1 death which happened in an exsanguinated subject, operated upon *in extremis*, after rupture of an aneurism. There were no cases of gangrene. There was one case of secondary hæmorrhage following a catgut suture, cured by an obliterative operation with silk. These additional cases increase our total collective list to 317 endo-aneurismorrhaphies up to September, 1919, of which 81 were performed in New Orleans and in the state of Louisiana, including 46 operations by the writer. These do not include 19 carotid, subclavian, innominate, iliac, and iliofemoral aneurisms, and cervical tumors requiring the extirpation of the common carotid, which were treated by the writer on the Halsted principle, either with the adjustable Matas-Allen aluminum band, applied proximally in the continuity of the vessel on the Hunterian plan, or by combining the band with the direct suture of the arteriovenous communication by the transvenous route. In all of these, complete operative cures were obtained, with the exception of 2 deaths from intercurrent or accidental complications (coronary heart disease and mesenteric thrombosis). These 19 cases do not include 16 additional applications of the band distally, or on the Brasdor plan, to the common carotid and subclavians, either simultaneously or consecutively, for the palliation of advanced aortic and innominate aneurisms, in which decided relief was obtained in approximately 30 per cent of the cases. At this

meeting 4 cases of endo-aneurismorrhaphy were added by Gaston Torrance, of Birmingham, Alabama; 4 by A. C. Scott, of Temple, Texas; 1 by Shelton Horsley, of Richmond, Virginia; and 1 by C. C. Coleman, of Richmond, Virginia—in all 10 successful cases, which increases the total number to 327 cases operated upon by my technique.

PERSONAL EXPERIENCES AND OBSERVATIONS IN THE TREATMENT OF ARTERIOVENOUS ANEURISMS BY THE INTRASACCULAR METHOD OF SUTURE, ENDO-ANEURISMORRHAPHY, WITH SPECIAL REFERENCE TO THE TRANSVENOUS ROUTE

In the preceding pages the surgical cure of arterial aneurisms by intrasaccular suture has been discussed. Now I desire to call attention to the advantages of the principles of endo-aneurismorrhaphy as applied to arteriovenous lesions.

The records of the world war have not only confirmed the experience of military experts that the coincident injury of the arteries with their satellite veins is one of the most frequent and characteristic injuries of the blood vessels in modern warfare, but they have shown that such injuries have exceeded the number in any previous war. At the front, 24.7 per cent of the wounded required special attention for injuries of the blood vessels, and at the base hospitals 2 per cent of the wounded were admitted for the treatment of traumatic aneurisms. This was due to the unprecedented preponderance of artillery and machine-gun fire. Of these vascular injuries fully 50 per cent and more involved both the artery and vein. The methods of treatment varied with the different belligerents. The Germans preferred to treat their cases by either lateral or circular suture, the French by extirpation and quadruple ligation, and the British usually by quadruple ligation with or without extirpation. While the Germans advocated early operations, within the first 3 weeks, the Allies delayed all operations, especially in arteriovenous lesions, until the collateral circulation had time to become fully established. In the last years of the war, the British and French reports showed a more frequent application of the suture, but still these cases were in the minority.

There is no single method of technique that is applicable to all varieties of arteriovenous aneurisms as these are met in practice. Some few of these aneurisms are susceptible of spontaneous cure; some are wonderfully well tolerated and do not call for any surgical treatment whatever, and still a few others, of long standing, are of such a forbidding character that they scarcely justify any surgical intervention whatever. The large majority, however, ultimately come to operation on account of disabling sequelæ and complications. The modern operations should always aim at conservatism. The operator should always approach these cases with the intention of at least saving the artery. There are, however, and always will be, cases in which the conservative principle of suture, which aims at the restoration of the functional integrity of the blood vessels, will have to yield—in the presence of insurmountable and forbidding anatomical and pathological obstacles—to the radical methods of ligation and extirpation, which are also to be regarded as conservative whenever they accomplish their purpose (cure) with the saving of limb and life.

But the experience of the author has proved to him that by the adoption of new technical suggestions, such as exhibited in this paper, the opportunities for the application of a conservative suture technique can be much enlarged, thereby reducing very considerably the number of radical ligations and extirpations which have been undoubtedly performed with unnecessary frequency and severity in the past, not only in recent military practice of this war, but in the current civilian practice of the day.

In reviewing the anatomy or morphology of arteriovenous aneurisms, I wish to call attention to several erroneous conceptions that are still found in the textbooks in regard to so-called varicose aneurisms. The old classical idea that an intermediary pseudo sac is interposed between the artery and the vein is an exceptional finding and not the rule. The wounded vessels are usually not detached or separated, their contiguity or parallelism

is not disturbed and the adventitious sac which communicates with the vessel is placed either in front or behind them, and only exceptionally between them.

The most frequent arteriovenous lesion is the aneurismal varix (varix aneurismaticus) the simple "phlebarterie" of Broca, in which contiguous vessels communicate by a direct arteriovenous fistula. These constitute more than 50 per cent of the cases in war and in peace; and this is fortunate from the operative point of view, because they are most easily cured by the simple closure of the orifice of communication through the vein. The method of approach by the transvenous route (Matas-Bickham procedure) accomplishes the one essential for the cure of arteriovenous aneurisms; viz., the complete exclusion of the arterial from the venous lumen, and thus restores the two blood streams to their normal channels, with the least disturbance and the minimum trauma.

This method of curing aneurismal varices is a direct derivative of the method of endo-aneurismorrhaphy in its restorative type, as applied to arterial aneurisms, in 1902, but which I practiced as far back as March 30, 1888. The application of the endo-aneurismal suture to arteriovenous aneurisms was first suggested and described by the author's friend and former associate, W. S. Bickham, now of New York, in a well-illustrated paper published in the *Annals of Surgery*, for May, 1904, and was again presented in all its phases in Bickham's *Operative Surgery* (3d ed., 1908) under the heading: "Operations for the radical cure of arteriovenous aneurisms, with preservation of circulation in the artery and vein (Matas-Bickham operation)."

In a personal experience of 205 surgical interventions upon the large vessels, I have recorded 24 cases of arteriovenous injuries of different types, in which I have used various methods of treatment. In this group the principle of endo-aneurismorrhaphy was used in 12 cases, viz., common carotid, 1; external iliac, 1; common and superficial femoral, 8; peroneal vessels, 1; subclavian, 1. In all of these the intrasaccular suture was applied to obliterate the orifice of communication, either by suturing all the orifices communicating with the pseudo sac in varicose aneurisms, or, in aneurismal varices by opening the sac formed by the dilated vein, and closing the fistula on the venous side (intravenously). This procedure was followed by the ligation of the vein and its obliteration immediately above and below the sutured anastomosis; or by detaching the vein from the artery after the obliteration of the orifice of communication had been accomplished by intravenous suture. The first clinical application of the transvenous route as a means of closing an arteriovenous fistula in the femoral vessels, on the Bickham-Matas principles was done by H. B. Gessner, the author's associate, on May 30, 1908. J. Chalmers Da Costa, of Philadelphia, cured a popliteal varix by the same procedure, with same modifications, in October, 1910. The author followed in a formidable case of jugulocarotid aneurism of 15 years' standing, in 1912, though he applied the suture to arteriovenous lesions by other methods as early as 1900. Then followed a number of other cases, in his practice and that of his associates, which gave him added opportunities to satisfy himself of the great technical value of the transvenous route in dealing with aneurismal varices, and of the intrasaccular suture in the so-called varicose variety.

The war with its vast opportunities for the development of the resources of vascular surgery, has yielded a comparatively small number of cases in which the transvenous route has been successfully utilized for the treatment of aneurismal varices. (Pearson, of Dublin, 1916; LeFort, Paris, 1917; Lecéne, Paris, 1917; and a few British surgeons mentioned by Sir George Makins, including his own cases, in his recent and excellent monograph on *Gunshot Injuries of the Blood Vessels*, 1919.) All of these observers extol the method for its simplicity and efficiency. Makins gives the transvenous route his unequivocal endorsement as the best method of curing pure aneurismal varices. All these writers seem to have come to the realization of the simplicity and value of this method rather late in their war experience, and with the exception of Lecéne and Forgue do not appear to be aware of its antebellum or American origin.

THE TREATMENT OF DUODENAL FISTULA

By STUART McGUIRE, M.D., F.A.C.S., Richmond, Virginia

THE increase in surgery and the more radical work now being done in the upper right abdomen has undoubtedly been attended by the production of many cases of traumatic duodenal fistula. While the aggregate number is large, no considerable number has developed in the practice of any one surgeon, hence very little has been written on the subject. This is to be regretted as the condition is a serious one and the best method of dealing with it has not yet been clearly settled.

A duodenal fistula usually follows an operation on the duodenum or an injury to the duodenum in the course of an operation on the gall-bladder or kidney. Such fistulæ sometimes develop immediately but more often are first noted 4 or 5 days after an operation at a time when the patient is supposed to be out of danger. This is due to stitches giving way or to tissue strangulated by a ligature or forceps undergoing sloughing. The discharge of duodenal and stomach contents may begin gradually and be small in amount, or it may begin suddenly and comprise all liquids and food taken by mouth and all the secretions of the stomach, liver, and pancreas. If the fistula is small and the discharge is scant the opening may close spontaneously and the patient recover, but usually the destructive action of the digestive secretions causes the fistula to enlarge, and unless there is surgical intervention the patient dies. The excoriative effect of the discharges on the wound and adjacent skin, the inability to retain nourishment taken by mouth, and above all the rapid loss of body fluids causes the patient to lose strength and weight in an alarming way. Often in a few hours the facial expression is so changed and the tissues of the body are so shrunken that it is difficult to realize that it is the same individual.

There are few conditions in surgery that require more courage and wisdom properly to meet; courage because a prompt operation must be done under unfavorable conditions on a patient who is thought to be safely convalescent, and wisdom because the best surgical procedure is not settled and different methods have to be adopted to meet different indications.

If the discharge is small or moderate in amount and the patient's general condition is good the fistulous opening may be plugged with gauze, little or no food or drink given by mouth, and the patient sustained by nutritive enemata with the hope that the opening in the duodenum may heal spontaneously. This conservative plan of treatment should not be continued if the patient loses strength rapidly, but more radical measures should be resorted to before it is too late.

Direct attack and suture of the opening in the duodenum is feasible in some cases but is hopeless in others. If the fistula has followed a nephrectomy and is due to injury inflicted on the posterior wall of the bowel, then the plan suggested and practiced by W. J. Mayo is the logical one. The abdomen should be opened by an upper right rectus incision and the duodenum exposed by retracting the gall-bladder and liver up and drawing the hepatic flexure and transverse colon down. An incision is then made through the peritoneum to the outer side of the duodenum and the bowel carefully separated from its posterior attachment. When the fistulous opening is exposed it can be easily and securely sutured.

If the fistula is on the anterior wall of the duodenum and has occurred as a complication after an operation on the gall-bladder or stomach, the conditions render an attempt at direct closure almost hopeless. The presence of infection makes manipulations dangerous, the existence of adhesions makes exposure difficult, and the inflamed and necrotic state of the bowel wall makes satisfactory coaptation with sutures impossible.

Deaver and others have dealt with the condition just described by doing a posterior gastro-enterostomy with or without closure of the pylorus. This side-tracks the opening in

the duodenum and prevents the escape from the intestinal tract of fluids taken by mouth. The operation is especially advisable when the fistula is the result of an ulcer of the duodenum, as it not only meets the immediate indications but also eventually cures the primary disease. It is an operation of some magnitude, however, and cannot be done without risk on a seriously ill patient, and it results in an anatomical abnormality that is to be regretted in many cases.

Recently I had a large duodenal fistula suddenly develop in a woman whose condition was such that a gastro-enterostomy could not be considered. The emergency was met by doing a simple jejunostomy and feeding her by the introduction of food into the intestines at a point below the fistulous opening. The procedure may not be original but I can find no reference to it in the superficial examination I have been able to make of the literature of the subject, and I have therefore decided to report the case.

Mrs. B., age 32, entered St. Luke's Hospital, July 21, 1919. She was very much emaciated, deeply jaundiced and had pulse and temperature indicating septic infection. She said that 8 months before admission she had a sudden attack of abdominal pain that was shortly followed by jaundice which had persisted with little or no variation. Four months ago she had been subjected to an operation, but the surgeon had not been able to locate and relieve her trouble. He told her that he found and separated many adhesions about the liver but that he could not palpate a stone, and therefore did not open the gall-bladder or common duct.

The patient's general condition made her a bad surgical risk but as it was evident she would die unless she was given relief, an operation was undertaken after acquainting the family with the dangers.

The abdomen was opened through the scar of the old incision in the upper right rectus. As anticipated, dense and widespread adhesions were found which were carefully and systematically separated. A small, thick walled gall-bladder containing several stones was finally reached, but in freeing it a hole was torn in the duodenum. As it was thought the opening might prove of use in the course of the operation it was not closed at the time but plugged with a piece of gauze. The common duct was next located. It did not contain a stone and was not dilated as had been expected but was empty and contracted. It was opened and a probe passed down it to the duodenum where it could be seen emerging at the ampulla of Vater. The probe was then passed up toward the liver and a stone was found at the bifurcation of the hepatic ducts. The stone was extracted and there was at once a copious flow of bile. The gall-bladder was removed, the opening in the duodenum sutured with a double row of chromic catgut stitches and the common duct drained by a tube sewed in its lumen with protective gauze and rubber tissue placed about it.

The patient stood the difficult and rather prolonged operation unusually well and her progress for a time was very satisfactory. On the ninth day, however, there was a sudden and profuse discharge of gastric contents through the incision, and it was evident that the catgut sutures in the duodenum had given way and a large duodenal fistula had resulted. Water and liquid food taken by mouth escaped through the wound almost as rapidly as swallowed and the patient's condition soon became desperate. She seemed actually to shrivel and shrink while under observation. It was obvious that something had to be done and done promptly. A direct attack on the fistula was hopeless owing to the condition of the tissues and a posterior gastro-enterostomy with occlusion of the pylorus was hopeless owing to the condition of the patient. The only alternative that suggested itself was a jejunostomy.

Under gas oxygen anæsthesia a new incision was made in the mid-line and the operation done by the technique described by Charles H. Mayo. The initial loop of the jejunum was brought into the wound, a small incision was made opposite its mesentery, and a rubber catheter inserted into its lumen. The catheter was retained in place by a purse-string suture and was infolded in the wall of the bowel for a distance of 2 inches, after the method of Witzel. The omentum was then placed in its normal position so that it lay between the loop of bowel and the anterior abdominal wall and a perforation was made in it through which the catheter was passed before it traversed the abdominal wall to be secured by a suture to the cutaneous surface.

The operation was completed in a few minutes and the patient was given a pint of fluid through the tube before she was removed from the table. The result was immediate and gratifying. All discharge except bile through the drain in the common duct shortly ceased and the patient's general condition rapidly improved. She was given water and nourishment exclusively through the catheter and nothing so introduced escaped through the fistula. At the end of 10 days the drain in the common duct was removed and in 3 weeks the primary incision had spontaneously closed. Feeding was cautiously begun by mouth and as it caused no trouble the tube in in the jejunum was taken out. The second incision closed promptly without leakage and the patient was ultimately discharged from the hospital having been relieved of her symptoms and having gained 20 pounds in weight.

SOME ABDOMINAL COMPLICATIONS OF INFLUENZA[1]

By ALEXIUS McGLANNAN, M.D., F.A.C.S., Baltimore

THE association of abdominal symptoms with the onset of respiratory diseases and the development of abdominal lesions as complications of such diseases occur with frequency sufficiently great to rob them of all claim to novelty.

The influenza epidemic gave an opportunity for extensive study of such occurrences and brought out several reports. I shall not attempt to discuss all the possibilities in this field, but shall comment on a few conditions observed during the epidemic.

Acute abdominal symptoms were present in a large proportion of the cases of influenza pneumonia. We did not note any definite relation between the area of pulmonary involvement and the abdominal symptoms. Acute appendicitis was the lesion most often mimicked, while the symptoms of cholecystitis and ruptured gastric and duodenal ulcer were also noted.

Hall and Dyas[2] suggest that the occurrence of symptoms of acute appendicitis in patients at the onset of influenza or pneumonia may be the result of bacterial invasion of the lymphoid areas of the appendix. As the abdominal symptoms were not persistent and their patients ran the average course of influenza, the process must have been limited to this primary invasion of the appendix.

What influence, if any, this sort of involvement of the lymphoid areas would have on the subsequent history of the appendix is not clear. If any appreciable reaction of the tissues takes place, it would seem to prepare the way for the later development of disease of the appendix. That such a sequel is possible, seems proved by the experience of Hall and Dyas at Camp Logan. They noted a great increase in the number of cases of acute appendicitis coming to operation in the 2 months immediately after the epidemic. The average incidence of appendicitis in the camp was 10.4 per 1000, but during the time mentioned it arose to 44.4 per 1000.

During an epidemic when the thoracic lesions are so emphasized, every one remembers the false abdominal symptoms, and mistakes in diagnosis are rare. Under ordinary circumstances one could easily confuse the symptoms of onset of acute appendicitis and those of pneumonia.

Asserson and Rathburn[3] call attention to the following valuable expedient. The area of maximum pain and tenderness is carefully mapped out. The patient is then directed to hold his breath. As long as the diaphragm is quiet, the referred pain and tenderness remain absent. This point helped us exclude an acute appendicitis in the case of a student, who was brought to the hospital with abdominal symptoms at the time of onset of his pneumonia on the second day of his attack of influenza.

X-ray examination of the chest may be an important aid in diagnosis. In one of our cases the plate indicated an area of consolidation, which could not be made out by physical examination of the chest. The symptoms were those of acute appendicitis, but because of the X-ray findings these symptoms were considered false. The patient went through a typical pneumonia and recovered.

Reginald E. Smith[4] notes that the pain and rigidity in the upper zone are referred along the course of the eighth, ninth, and and tenth intercostal nerves. Less frequently, the eleventh and twelfth nerves have caused the referred pain. On two occasions Smith blocked the eighth and ninth nerves, and the symptoms disappeared. He divides the abdominal complications of influenza into three types of lesions:

1. Acute streptococcus peritonitis, which is hæmatogenous in its origin and often associated with streptococcus endocarditis.
2. Acute dilatation of the stomach, a toxic manifestation.
3. Co-incident acute abdominal lesions.

[2] J. Am. M. Ass., 1919, lxxii, 726.

[3] U. S. N. Med. Bull. No. 1, p. 29.

[4] Lancet, 1919, Mar. 15, I, p. 421.

[1] Read before the Southern Surgical Association, New Orleans, December 16, 1919.

During the epidemic of last year, all complications were small in number, because so many patients died in the first days of the illness as a result of the intense infection.

A hæmatogenous peritonitis of varying extent is one of the commonest abdominal complications of influenza. When this peritonitis is a diffuse one, it is a part of a severe generalized infection and does not give the usual picture of such a peritonitis. Beals, Blanton, and Eisendrath[1], in their report, note that in six such cases coming to autopsy, the diagnosis had been made but once.

Subphrenic abscess and localized peritonitis in the region of the diaphragm could easily be confused with thoracic disease, just as a thoracic lesion may give symptoms similar to those of ruptured gastric ulcer, cholecystitis, or appendicitis.

Reginald E. Smith gives certain points which his experience has shown to be of value in distinguishing between true and false intra-abdominal catastrophies occurring as complications of influenza:

1. Movements of the alæ nasi. In the absence of other signs of thoracic disease, abdominal pain associated with movements of the alæ nasi during respiration, indicates a thoracic and not an abdominal lesion. The movement of the alæ, if not present, can be brought out by slight exertion. Such movements of the nose come only in the latter stages of peritonitis, never early in the disease.

2. Dullness in the flanks never indicates a visceral inflammation or a resulting peritonitis, except in the cases of acute hæmatogenous infection of the peritoneum. In these latter cases, the localized pain and other characteristic symptoms of diffuse peritonitis are lost in those of the severe general infection.

3. The facies is that of influenza, not of peritonitis. The anxiety is lethargic and resigned, not terror-stricken and active. It is of the medical rather than the surgical type.

One of our cases illustrates Smith's second point.

The patient, a young colored woman, was admitted to Mercy Hospital, with an influenza pneumonia. She had a temperature of 102.5° and was expectorating thin, purple sputum. She was intensely toxic and apathetic, but not unconscious. The chest signs were those of bronchopneumonia. The abdomen was distended, there was shifting dullness in both flanks, with muscle spasm in the left upper quadrant. There was no œdema and the urine was free from albumin and casts. Except for this muscle spasm, there were no signs of peritonitis. The patient died about 24 hours after admission. We were unable to secure an autopsy, but it seems reasonable to conclude that the peritoneal exudate was the result of a general infection so overwhelming that the ordinary signs of peritonitis were lost.

Thrombophlebitis. The usual situation of an infectious obstruction of the blood vessels is in one of the veins of the leg. Such a thrombophlebitis of the femoral vein may be the starting point for an occlusion clot which will extend into the vena cava and over into the iliac vein of the opposite side. In addition to this form of abdominal thrombophlebitis, it is known that thrombosis may begin in any branch and involve the cava by direct extension, or that a primary thrombosis of the vena cava itself may occur as a complication of one of the acute infectious diseases.[2] In one case we made the diagnosis of obstruction to the vena cava in the region of the hepatic veins.

The patient was a young white man, who passed through a severe influenza pneumonia. He was markedly cyanosed from the onset, and suffered from girdle-like pains in the lumbar and epigastric regions. The intestines were considerably distended and he was constipated. About the fifteenth day of his illness he developed ascites. The physical signs indicated a considerable quantity of fluid in both flanks. The epigastric pain continued and there was slight tenderness just to the right of the vertebræ in the upper quadrant of the abdomen. There was persistent rise of temperature to about 102°. The skin of the abdomen and back was purple red in color. The patient gradually recovered. The fluid was slowly absorbed, and the circulation in the skin gradually became normal.

In this case collateral circulation must have been established by the deep channels as in the case reported by Andrew[3].

Coincident abdominal lesions include the perforative inflammations of the hollow viscera. In studying the cause of these perforations the case reported by Crowley[4] is worthy of

[1] J. Am .M. Ass., 1919, lxxii, 880.

[2] J. H. Pleasants. Johns Hopkins Hosp. Reports, xvi, 363.

[3] Quoted by Pleasants. Loc. cit.

[4] J. Med. Research, 1919, p. 339.

consideration. In this case a patient, age 22, died 25 days after the onset of influenza, which was complicated by pneumonia and empyema. At autopsy, among other lesions, there was found an ulcerative condition of the ileum, cæcum, and colon. The ulcerated areas contained a mycobacillus, which was not present in the chest lesions. Crowley concludes that the organism is a cladothrix, and that the chronic sepsis produced by the influenza and its complications so reduced the individual that an organism, ordinarily nonpathogenic, became invasive.

Beals, Blanton, and Eisendrath enumerate rupture of the rectus muscle as an abdominal complication.

We had no case of ruptured rectus, but had one abscess develop in the scar of an appendectomy, which had been healed for nearly three years. The abscess came on during convalescence from the pneumonia, after the patient had been free from fever for more than 2 weeks. The abscess was situated in the rectus muscle outside the peritoneum. The patient recovered after incision and drainage of the abscess.

REPAIR OF PERIPHERAL NERVE INJURIES[1]

By G. CARL HUBER, M.D., Ann Arbor, Michigan

FROM February, 1918, to March, 1919, the office of the Surgeon General detailed in succession Drs. Dean Lewis, J. F. Corbett, Byron Stookey, and T. Roberg to assist in promoting the study of peripheral nerve repair. These surgeons in succession performed the experimental operations, and I am greatly indebted to them for their hearty co-operation. The work was well done; throughout careful asepsis and great care in technique was exercised. In the several series of experiments undertaken, the respective animals were kept under observation for from a few days to nearly a year. At fixed times the animals operated upon were killed, the nerve operated upon exposed, gross observation recorded; if profitable, functional tests were made; and in all cases the nerve operated upon removed for histological study. The great bulk of the sections made were of tissues stained after the pyridin silver method, which gives especial differentiation of the neuraxes. Other fixing and staining methods were used as opportunity permitted or necessity demanded. In all approximately 70,000 sections are the outcome of this series of investigations—a wealth of material that should enable us to answer many questions. Naturally the work had to shape itself with reference to a practical, surgical side. In all 21 series of experiments were undertaken, totaling 279 operations.

In the early part of this work, Dean Lewis and I were interested in the study of the development of the amputation neuroma, especially in methods for obviating its formation. It was found early that the formation of the amputation neuroma could be prevented by the injection of absolute alcohol into the distal end of the severed nerve. In this series we list 37 experiments. The operations were made on the sciatic nerve of rabbits. After exposing the nerve and freeing it from its bed for a distance of 2 to 5 centimeters, the nerve was injected with about 0.5 cubic centimeters of absolute alcohol, often in two or three point injections, the needle directed upward, depending on the size of the nerve. The nerve was then cut 5 millimeters to 8 millimeters distal to the place of injection and often a segment of the distal sciatic removed. An escape of a small amount of absolute alcohol into the wound does not appear to be of consequence, since no material increase of connective tissue was noted as a result. It was found that this procedure obviated the formation of an amputation neuroma. In all of the experiments of this series, kept for a period of more than three

[1] Read before the Chicago Surgical and Chicago Neurological Societies. (For Discussion, see p. 530.)

weeks, the peripheral end of the central stump runs out to a fine point, much like that of a sharpened pencil, and maintains this form for at least 5 months. Structurally considered, there is evident no neuroma formation, no proliferation of sheath cells, no marked proliferation of connective-tissue ends. Beginning with the fourth to the fifth week after operation, a down-growth of central neuraxes into the alcohol-injected field is evident. But these neuraxes have a very regular course and do not exhibit the tangling and crisscrossing observed in a neuroma. In a second series there are listed 21 operations which served as controls. In these the sciatic of rabbits was cut and resected, but no absolute alcohol was injected. These experiments were carefully done, aseptic and practically bloodless. In every experiment kept longer than 15 days, there was developed an amputation neuroma. It is not necessary to have present an infection in order that an amputation neuroma develop. An amputation neuroma should be regarded as an attempt on the part of the severed nerve at regeneration.

In a further series of control experiments, 12 in number, the sciatic of rabbits was exposed, injected with absolute alcohol in place, without consequent severance of the nerve, as is now and then done for the treatment of neuralgia. In each case paralysis followed. Beginning with about 4 weeks after the alcohol injection, down-growths of central neuraxes may be observed in sections. Such down-growing neuraxes grow through the injected area and there results a regeneration of the peripheral part of the nerve. In a series of 3 experiments, full strength acetone was used in place of absolute alcohol. Immediate paralysis, with ultimate return of function, was noted. However, an increase of the connective tissue of the nerve was noted more than when absolute alcohol was used. In all of our experiments absolute alcohol was used for injection. Dean Lewis has reported this evening on the favorable results obtained in the treatment of three cases of causalgia after exposure of the respective nerves and injection of 60 per cent alcohol. I cannot state whether the injection of alcohol of this strength would prevent the formation of an amputation neuroma. Experimentally considered there appear to be no deleterious results from the use of absolute alcohol.

By far the greater number of our experimental observations deal with the question of nerve transplantation. It is, of course, fully understood that when it is possible to bring together the severed ends of a nerve and make end-to-end suture, without undue tension, even when it is necessary to use proper posture, this is the operation of choice. In case the severed nerve ends cannot be brought together, the question of using a nerve transplant should be considered, that is, using a segment of another nerve of requisite length to bridge the gap. Following surgical usage, a nerve segment taken from another nerve of the same individual is designated as auto-nerve-transplant; if from a nerve of another individual, but of the same species, a homo-nerve-transplant; if from another individual but of another species, a hetero-nerve-transplant. I am aware that surgeons are not in accord with reference to the practical value of nerve transplants; experimentally, convincing evidence of their practicability can be presented.

Our experimental observations are grouped under the following series: We have a series of 17 experiments on the sciatic nerve of dogs in which after resection to the extent of nearly 3 centimeters, the gap was bridged by using as an autotransplant, one or several segments of the cutaneous radial of the opposite side. This latter nerve has a diameter which is much smaller than that of the sciatic, thus presenting a problem not unlike that met with in practical surgery; namely, of making use of one of the less essential cutaneous nerves to bridge a gap in one of the major nerves. The disparity of the size of the transplant and resected nerve was met in 6 of these experiments by suturing four segments of the cutaneous radical between the resected sciatic ends. This we have spoken of as a cable-auto-nerve-transplant, and must regard it as an operation, judging from experimental results, deserving consideration in practical surgery. Of these 6 experiments, that of the shortest duration terminated in 11 days;

that of the longest in 382 days. In all of them the funicular structure of the transplanted nerve segments was fully maintained. The four transplanted nerve segments early became surrounded by a common connective-tissue sheath, serving as an epineural sheath. In one of the experiments, terminated 26 days after operation, down growing neuraxes are found to have penetrated all of the several funiculi of the four transplanted nerve segments to the extent of approximately 2 centimeters, thus nearly reaching the distal wound. In the experiments of longer duration down-growing neuraxes are found to have reached the distal sciatic with ultimate recovery of function in the calf and interossei muscles, as tested functionally and noted in microscopic preparations.

In human surgery, segments taken from the cutaneous radial, the musculocutaneous and the crural nerves may be thought of as sources for auto-nerve-transplants.

A series of 6 experiments deals with homo-nerve-transplants. The sciatic nerve of rabbits was resected and a segment of suitable length taken from the sciatic of another rabbit was used to bridge the defect. This operation can, of course, be readily done in experimental surgery; its applicability to human surgery is obviously restricted when use is made of a fresh homo-nerve-transplant. I shall later refer to other series of homo-nerve-transplants, which have a more practical bearing. In the series under discussion, 4 of the animals were under observation for periods varying from 17 to 83 days. In each of these experiments down-growing neuraxes had either penetrated the central end of the transplant or extended through it and reached the distal sciatic, justifying the use of a homo-neuro-transplant.

We have a series of 39 experiments dealing with hetero-nerve-transplants. In the majority of these, one segment or two segments of the sciatic of a guinea pig was used to bridge a defect in the sciatic of a rabbit, caused by resection. In 3 experiments a nerve taken from a dog was used for this purpose. The duration of the several experiments varied from 3 to 358 days. The value of the use of hetero-transplants is, I believe, still under consideration in surgery with prevailing opinion against justification. This series of experiments is perhaps more of academic than practical interest, and will thus be summarized here only very briefly. At the outset it may be stated that while regeneration through a hetero-nerve-transplant may be obtained experimentally, the outcome is less certain and less satisfactory and in general requires longer time than when auto- or homo-nerve-transplants are employed. In serial sections of nerves obtained from many of the series in which new neuraxes were found in the distal nerve, it can be shown that many of the down-growing neuraxes pass outside of the nerve transplant and thus reach the distal nerve segment, the hetero-nerve-transplant thus serving only indirectly in guiding neuraxes distally. The mere study of the return of function does not adequately consider this question; a study of serial sections of the nerve involved is necessary.

It is a well-known observation that transplanted nerve segments undergo structural change after transplantation, whether auto- homo- or hetero-nerve-transplants. The process is not identical in the three types of nerve transplants, but this need not engage us for the moment. It occurred to Dean Lewis and myself that since a nerve transplant degenerates after transplantation, the process of regeneration through a nerve transplant might be facilitated and hastened by using as a transplant a segment of a nerve already in process of wallerian degeneration. A further series of experiments was thus undertaken in which degenerated auto-, homo- and hetero-nerve-transplants were used to bridge defects in resected nerves. It may be stated at the outset that our hypothesis was not substantiated. The experiments follow:

In 3 experiments a degenerated auto-nerve-transplant was used. The sciatic of a dog was cut and the wound closed. Some 20 to 30 days later, a segment of the distal degenerated sciatic was used to bridge a defect in the resected ulnar of the same dog. The several experiments ranged from 127 to 416 days. Regeneration was obtained through the transplant, but there is no indication that regeneration took place more satis-

factorily and more rapidly than it would have if an undegenerated auto-nerve-transplant had been used.

In a series of 5 experiments, degenerated homo-nerve-transplants were tested. These experiments ranged over a period varying from 17 to 328 days. In one of these experiments terminated 37 days after operation, in which a segment, 3.4 centimeters in length, from a sciatic of a dog degenerated 27 days, was transplanted to the sciatic of another dog, new neuraxes budding from the central sciatic stump were found nearly the whole length of the transplant. In experiments of longer duration peripheral regeneration was obtained. These two series may perhaps serve to show that degenerated auto-and homo-nerve-transplants may be used with assurance of success if opportunity presents.

We shall report on a series of 16 experiments dealing with degenerated hetero-nerve-transplants, the duration of the several experiments varying from 7 to 244 days. A nerve of a dog degenerated for several weeks was used to bridge a defect caused by resection of the sciatic of a rabbit. The syncytial nucleated bands which develop in a degenerated peripheral nerve may, in a measure, be regarded as representing a reversion to embryonic structure. The thought suggested itself that such tissue might be more suitable than an undegenerated nerve for a hetero-nerve-transplant. This was not found to be the case. The results of these experiments may be summarized by stating that a degenerated hetero-nerve-transplant was found to be less serviceable than a non-degenerated nerve, owing to the fact that a further degeneration ensues resulting in the formation of a tissue detritus which offers an effective block to down-growing neuraxes. Whether this block is largely mechanical or also in part of a chemical nature has not been determined.

The difficulty of obtaining on demand fresh homo-nerve-transplants in surgical practice led us to consider experimentally certain methods of storing nerves for a period of weeks before use as nerve transplants.

Dujarier and Francois[1] speak of using human nerves stored in vaseline at approximately 2° C. for periods varying from 2 to 5 weeks. Some 20 cases are reported but before sufficient time had elapsed to determine the efficacy of the method. We list a series of 8 experiments on the sciatic on rabbits in which this method was tested. Following in general the directions of the French authors, the sciatic nerve of the rabbit was removed and placed in a tube containing sterile vaseline. The tube was then corked with sterile cotton plugs and placed in a small ice chest kept at a temperature of about 3° C. At the end of approximately two weeks, the tube was taken from the ice chest and warmed sufficiently to melt the vaseline. The nerve was then removed and washed in sterile rabbits' serum, when it was ready for use as a nerve transplant. The duration of the several experiments varied from 66 to 155 days. In all, down-growths of central neuraxes to and through the transplant and distal sciatic were noted. For experiments of longer duration, more than 3 months, functional return in calf muscles was noted. From a histologic study of the nerve removed, it is clear that central neuraxes grow through a homo-nerve-transplant stored in vaseline quite as readily as through a fresh homo-nerve-transplant.

The method of Dujarier and Francois of storing nerves in vaseline is not readily carried out and certain steps appeared to us unnecessary. We, therefore, developed a method of storing nerves in liquid petrolatum. This method is simpler of application and equally effective. Sciatic nerves removed from rabbits under aseptic precautions were placed in sterile liquid petrolatum kept in long tube vials corked with sterile cotton plug. These tubes were then placed in a small ice chest, kept at a temperature of 3° C. There they remained for periods varying from 7 to 39 days. When required a tube was taken from the ice chest, the nerve removed from the liquid petrolatum, held at one end with forceps and allowed to drain until no more liquid petrolatum dripped off, sutures were then placed at the desired interval and the nerve segment cut to desired length, for the majority of cases about 3 centimeters, and then transplanted to a resected sciatic

[1]Bull. et mém. Soc. de chir., Par., 1918. Jan.

of a rabbit. In all we list a series of 40 experiments dealing with homo-nerve-transplant stored in liquid petrolatum. This method of storage is simple and easily carried out. The small amount of liquid petrolatum adhering to the nerve does not appear to influence the course of the experiment. No infection was noted in any of the experiments; the wounds healed readily and satisfactorily. Of these experiments 20 were carried on for periods of 3 months or longer, the longest for a period of 276 days. In all of these, where functional tests could be made, return of function in the calf muscles was noted; for longer time experiments return of function in the foot interossei muscles also. In sections derived from the nerves operated upon which were removed in these cases, down-growing neuraxes were found in the distal sciatic, in the smaller muscular branches, as also motor nerve endings in the muscle. In so far as experimental evidence admits of judgment, homo-nerve-transplants stored in liquid petrolatum for a period of about 5 weeks may be regarded as serviceable material for use in bridging defects in nerves.

A further series of 19 experiments deals with homo-nerve-transplants stored in sterile 50 per cent alcohol at room temperature. Nageotte, a French scientist, has reported experimental work in which the sciatic nerves of calves, newborn or stillborn, were stored for periods in 50 per cent alcohol and then used as nerve transplants, in his experiments as hetero-nerve-transplants. This method has, I believe, been given some consideration by certain French surgeons. During Dr. Roberg's association with me, the series of experiments on homo-nerve-transplants stored in 50 per cent alcohol at room temperature was undertaken. Fresh sciatic nerves of rabbits were removed under strict asepsis, placed in sterile bottles containing 50 per cent alcohol for periods varying from 10 to 30 days, and kept at room temperature. When needed for transplantation a nerve segment was taken from the alcohol and placed for 10 to 20 minutes in warmed, sterile saline solution, sutures passed, the nerve cut to required length, approximately 3 centimeters, and then used as transplant. In 8 experiments of this series the period of observation was longer than 3 months and in each of these regeneration of the distal nerve through the transplant was attained. Functional return in calf and in foot muscles was obtained.

The supposition is permissible that, in nerves stored in sterile vaseline and liquid petrolatum at a temperatrue of 3° C., some degree of viability of certain tissue elements, sheath cells and connective-tissue cells is retained, even though there is no satisfactory evidence of the proliferation of the sheath cells of the transplanted nerve fibers nor their participation in the down-growth of central neuraxes. In the case of alcohol-stored nerves, it cannot be supposed that viability is retained by any of the tissue elements of the stored nerves. Therefore, the supposition seemed justified that hetero-nerve-transplants stored in liquid petrolatum or especially alcohol would prove more satisfactory than fresh hetero-nerve-transplants.

A series of 6 experiments were undertaken to test the value of hetero-nerve-transplants stored in liquid petrolatum. Segments were taken from nerves of dogs and stored in liquid petrolatum after the manner previously indicated, which after 10 to 20 days were used as transplants to bridge defects in resected sciatic nerves of rabbits. The several experiments range in duration for periods varying from 5 days to 138 days. The results attained may be summarized by stating that in no instance was successful regeneration through a hetero-nerve-transplant stored in liquid petrolatum attained.

A series of 3 experiments is listed in which a nerve segment removed from a dog was stored in 50 per cent alcohol for a period of 10 days and then used to bridge a defect in the sciatic of a rabbit caused by resection. The several animals were under observation for periods varying from 64 to 154 days. Some down-growth of central neuraxes through the nerve transplant was obtained, though not of sufficient extent to give functional return in calf muscles. Judging from the limited number of experiments it would seem to appear that hetero-nerve-transplants stored in 50 per cent alcohol do not offer nearly as good a

medium for the down-growth of central neuraxes as does a homo-nerve-transplant stored in 50 per cent alcohol.

In another series of experiments, the wrapping of a transplant and suture line with a membranous sheath, perhaps with a view of presenting encroachment of surrounding connective tissue or retaining down-growing neuraxes within a limited field, was studied. English and French surgeons have, to some extent, made use of membranous sheaths in operations of peripheral nerve repair. So far as I am aware, their value has not been studied experimentally. It was fully recognized that certain conditions realized in peripheral nerve repair, such as dense scar tissue, could not be reproduced in experimental work carried out in normal tissues. However, it was hoped that some facts of practical value might be ascertained. The experiments were all performed on the sciatic of dogs, resected and bridged by means of auto-nerve-transplants taken from the ulnar nerve of the same dog. After the nerve transplantation was completed, the field of the transplant and the central and distal suture lines were wrapped with a sheath, which sheath differed in the several series of experiments.

This series includes 14 experiments in which the auto-nerve-transplant and the suture lines were wrapped with Cargile membrane in one or several layers. In 8 of these experiments the Cargile membrane as found in the market was used. It was noted that Cargile membrane thus used is relatively quickly absorbed, so that after about 10 days very little trace could be found of it in the tissues. Cargile membrane used in this form can have little use, owing to its rapid absorption. The difficulty of obtaining Cargile membrane at the time these experiments were under way, led me to place into 70 per cent alcohol portions of a membrane not used in any one experiment with a view of resterilizing the same. After a time these pieces of membrane were placed in absolute alcohol, usually for about 24 hours, and before use in an operation taken from the absolute alcohol, spread out on a dry, sterile towel and allowed to dry. Cargile membrane thus treated we speak of as "alcoholized Cargile membrane." In 6 of the experiments of this series alcoholized Cargile membrane was used to ensheath the autotransplant and the suture lines. Much to our surprise, alcoholized Cargile membrane is not absorbed within a period of 5 to 6 months. Such a membrane does not appear to incite connective-tissue formation. It remains closely adherent to the transplant and the resected nerve ends and does retain within the limits of the membrane the down-growing neuraxes. It does not appear to influence, either for or against, the down-growth of central neuraxes through the transplant, but facilitates the down-growth of such neuraxes as are found in the connective tissue surrounding the transplant. It is considered that a sheath of alcoholized Cargile membrane may serve a useful purpose in peripheral nerve surgery.

In a series of 14 experiments an autofascial sheath was made. In this series after making an auto-nerve-transplant on the sciatic of a dog, the fascia lata of the same side as the nerve operation was exposed and an oblong strip about 2 centimeters wide and 5 to 6 centimeters long was removed. This fascial membrane, with its smooth side toward the nerve was then wrapped about the transplant and the suture lines, retained in place and in the form of a tube by means of central and distal stay sutures and several intervening half mattress sutures. These experiments varied in duration from 14 to 326 days. It is of interest to note that even in the longer time experiments, extending for a period of nearly a year, the autofascial sheath remained clearly defined and without material absorption. There is incited an increase of connective-tissue growth without and within the sheaths, which argues against the use of these sheaths in practical surgery. The nutrition of the transplant within the sheath does not appear to be influenced by the presence of the sheaths, since regeneration through the transplant was obtained in all experiments observed for a sufficient length of time to admit of it.

In a further series of 6 experiments the auto-nerve-transplant was wrapped with a formalized arterial sheath. These sheaths

were prepared by stretching the carotid arteries of large dogs over glass rods of suitable size, fixing the same in 5 per cent formalin for 48 hours; washing in flowing water, 24 hours; boiling 20 minutes and storing in 70 per cent alcohol. When required for use, an artery thus treated was slipped from the glass rod, cut to required length, placed for 30 minutes in warmed, sterile saline solution, and then split longitudinally along one side. This sheath was then slipped over the transplant and suture lines, held in place by central and distal stay sutures and several intervening half mattress sutures, thus forming an arterial tubular sheath surrounding transplant and the suture lines. These experiments were under observation for periods varying from 6 to 241 days. It is of interest to note that an arterial sheath, treated as here indicated will remain in place, unabsorbed and without inciting much connective-tissue formation for a period of at least 6 months. The new neuraxes that grow distalward, outside of the transplanted nerve segment are retained within the arterial sheaths. This type of sheath presents no advantages over an alcoholized Cargile membrane sheath and is not so easily prepared and applied. It incites less connective-tissue formation than does an autofascial sheath.

Our list of experiments contains only 2 experiments in which an auto-nerve-transplant was wrapped in a fat sheath. In these two experiments after completing the operation of auto-nerve-transplant, a segment of ulnar to sciatic, the transplant and suture lines were wrapped by means of a fat layer taken from the subcutaneous fat of the same animal, and held in place by stay sutures. One of the experiments was terminated by death of the animal 4 days after the operation. The other was continued 238 days. In the latter experiment, while regeneration of the distal nerve was obtained through the transplant, the fat sheath was entirely replaced by dense connective tissue, so that in the field of operation the nerve trunk was surrounded and bound down by extensive connective-tissue formation, more so than observed in any other type of operation. This argues strongly against fat sheaths in peripheral nerve repair.

In a further series of 13 experiments we made use of an arterial tubular suture to bridge a defect in a resected nerve. Arterial tubular sutures were experimentally tested by Foramitti. This method of nerve repair was used to some extent by Hashimoto in the Russo-Japanese War; by other surgeons in the first and second Balkan Wars. In our experiments we followed Foramitti in the preparation of the arterial tubes, however, using the carotid artery of dogs instead of the carotid arteries of calves as recommended by Foramitti. The arterial tubes were prepared by stretching the carotid arteries of large dogs over glass rods of suitable size fixing them in 5 per cent formalin for 48 hours; washing for 24 hours in flowing water; boiling for 20 minutes; then storing in 70 per cent alcohol, in which they may be kept for days. When required for use an artery thus treated was taken from the alcohol, slipped from the glass rod, cut to required length and then placed in warmed, sterile saline solution for about 30 minutes. The manner of use for bridging is as follows:

A suture threaded at both ends with a fine needle is passed through the central and distal end of a cut nerve several millimeters from the cut ends. Centrally and distally the needles are then passed through opposing side of the arterial tube near the two ends of the tube, and the resected nerve ends drawn into the lumen of the artery and held in place by tying the suture over the artery. In the several experiments of this series, the time of observation varied 6 days to 298 days. It is interesting to note that arterial tubes prepared as above indicated, when placed in position in tubular sutures are not absorbed for a period of at least 5 months. Their presence in tissue does not especially incite connective-tissue formation. There is practically no penetration of connective tissue through the wall of the tube and a negligible in-wandering of leucocytes through the arterial wall. A small amount of connective tissue is found within the lumen of the arterial tube in long time experiments, derived, I believe, from the resected nerve ends. In 4 of the experiments kept longer than 4 months, down-growing neuraxes derived from the central stump

had passed through the lumen of the artery, in one experiment a distance of approximately 4 centimeters, and reached the distal nerve, in which beginning regeneration was noted. While regeneration through an arterial tube is a possibility, this method does not commend itself for surgical practice since it is less certain of favorable results than when auto- or homo-nerve-transplants are used.

In certain of our experiments in which the ulnar nerve was resected to the extent of 4 to 5 centimeters for the purpose of obtaining a nerve segment to be used as an auto-nerve-transplant in another operation, the resected ulnar nerve ends were brought together as closely as possible by means of a tension silk suture. In certain of these experiments the suture line was wrapped with Cargile membrane; others with formalized arterial sheath. The leg operated upon was not immobilized. Of the 13 experiments of this nature in all but 2 the tension suture gave way, admitting a separation of the resected nerve ends. In the two experiments in which the suture maintained, down-growth of central neuraxes to the distal segment was noted. It is recognized that this series of experiments does not warrant drawing more than limited deductions as to the value of tension sutures. Immobilization of parts did not seem practicable. They may serve to show that sutures alone are not sufficient to retain resected nerve ends in position if undue tension is used to bring the nerve ends together.

By way of final summary the following points may receive special consideration:

The results of all the experimental work on nerve transplantation indicate clearly, it seems to me, that the most favorable results are to be obtained after the use of auto-nerve-transplant and for practical surgery a cable-auto-nerve-transplant, using several segments of a cutaneous sensory nerve to bridge a defect in a larger motor-sensory nerve. The question of the type of nerve is not material; the question of the funicular arrangement is of secondary importance; whether the central or the distal end of transplant is placed centrally is not necessary of consideration; accurate end-to-end suture, careful technique, and dry field, are essential, I believe.

As concerns fresh homo-nerve-transplants. I believe I am justified in stating that they serve the purpose of bridging nerve defects quite as well as auto-nerve-transplants, if available, which would very probably not often be the case in practical surgery. I believe that experimental observations justify the use of stored homo-nerve-transplants; nerves stored either in sterile vaseline, sterile liquid petrolatum, or even 50 per cent alcohol. If nerves can be stored under proper precautions for 40 days in liquid petrolatum and serve as transplants, I see no reason why they may not be stored 80 days or even longer. The favorable results obtained after using nerves stored in 50 per cent alcohol indicate that value of the nerve transplant is not dependent on the presence of living sheath cells and there is no question of the nerve fibers of a nerve segment stored in 50 per cent alcohol undergoing wallerian degeneration as does the peripheral part of a nerve after section. The neurilemma sheaths maintain and through these the central neuraxes reach the distal nerve segment.

As concerns the general question of the use of sheaths about nerve suture lines or transplants, it may be stated that as a general rule sheathing is not necessary, and while perhaps not harmful, they serve no specific purpose. Considered in the light of our experimental work the use of an alcoholized Cargile membrane sheath may be justified in certain cases. There is very little connective-tissue formation consequent to their use; they remain in place unabsorbed for nearly 5 months after being placed in the wound. I should like to see this method of sheathing tried in cases in which much fibrous tissue is present in the field of nerve repair, especially in cases in which it is not possible to do muscle neurolysis as has been so successfully done by Dean Lewis in certain cases.

There is one more point I should like to refer to in connection with our experimental work, namely, the importance of having dry, clean wounds, before the wound is closed. There would appear to be a correlation between a field not quite dry and an increase of connective tissue about the nerve operated upon.

THE CLINICAL SIGNS OF NERVE INJURY AND REGENERATION[1]

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CLINICAL signs of nerve regeneration arethe manifestations of the spontaneous recovery of an injured nerve or the recovery consequent to the suture of the ends of a divided nerve or that following some operative procedure performed upon an injured nerve which has shown signs of physiological interruption. To a large degree, signs of regeneration consist in the evidence of return of function. It is necessary, therefore, to define the signs of loss of function.

Many attempts have been made to discover a sign or groups of signs which would justify a rapid differential diagnosis between a case having a complete anatomical section of a nerve and one in which complete loss of function is not the result of division of the nerve. Similarly, attempts have been made to differentiate between those cases which have had complete loss of function and which spontaneously recover and those cases which do not recover spontaneously but require surgical interference.

At one time it was thought possible to distinguish several definite syndromes. Prominent among these were the groups adopted by Mme. Dejerine and J. Mouzon.[2] They defined the syndromes of interruption, of compression, of irritation, of dissociation, and of recovery, each having a distinctive group of symptoms. Unfortunately, it was proven by others by subsequent observations that this classification was artificial and unreliable for the purpose of certain diagnoses.

To my knowledge there is no way by which the complete loss of function due to anatomical interruption can be differentiated from the complete loss of function due to physiological interruption produced by compression, etc. From a single examination, at a given time, we can only determine whether the lesion is complete or incomplete. If the lesion is complete we cannot tell whether it is due to anatomical interruption or not, nor can we predicate whether it will spontaneously recover or require surgical treatment. Of course, if the lesion is incomplete, anatomical division cannot be present except in the form of a lateral notch.

In a case of complete physiological interruption, only when a subsequent examination shows some return of function may we say that the lesion is incomplete and an anatomical interruption absent. No other sign or group of signs suffice. In general, the course of the clinical picture is much more important than any group of signs for the purpose of determining the severity of a lesion.

The various clinical signs resulting from a complete interruption of a nerve have been given a different value and significance by different investigators. Each one has proposed a certain grouping of symptoms in the order of their supposed value and many have added certain signs of their own. Common to most may be found, (1) complete paralysis of all muscles supplied by the nerve below the lesion; (2) complete reaction of degeneration; (3) rapid and extensive atrophy of the paralyzed muscles; (4) absence of pain on pressure applied to the nerve trunk below the lesion; (5) loss of objective sensibility in the supply of the affected nerve. Many include absence of tonicity with characteristic attitudes of the limbs in repose, as wrist-drop, foot-drop, etc., absence of any pain on pressure of the muscles supplied by the injured nerve, exaggerated excitability of the muscles to mechanical stimuli, abolition of corresponding reflexes, absence of any zone of hyperæsthesia or paræsthesia in the region supplied by the injured nerve, vasomotor and trophic disturbances.

Much of the difficulty in determining the presence or absence of severe lesions may be attributed to the lack of standardized methods of examination, careless and verbose descriptions, and lack of knowledge of the physiology of the peripheral nervous system.

[2] Presse méd., 1915, May 10, July 8, August 30.

[1] Read before a joint meeting of the Chicago Surgical and Neurological Societies, January 2, 1920. (For discussion see p. 530.)

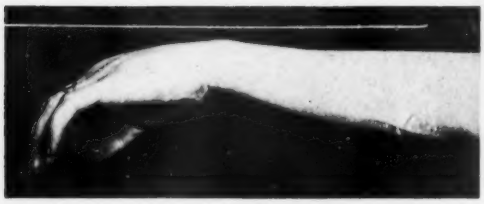


Fig. 1. Wrist drop in musculospiral palsy.

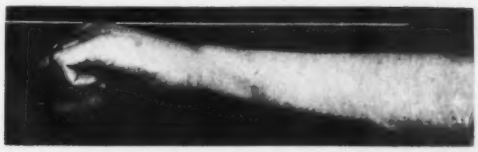


Fig. 2. Extension of wrist by supplementary movement of flexion of fingers.

So much is this true, that in describing the sensory changes present in severe lesions of peripheral nerves, it was necessary for one distinguished author to refer to them as "considerable disturbances of objective sensibility." If a complete interruption of a sensory or mixed nerve be present, complete loss of sensory function would follow, and if we knew how to determine it and of what it consisted, recourse to such descriptions would be unnecessary.

Because of these difficulties I shall define the extent to which I believe the loss of such functions as I consider most important, may be employed in determining the severity of a peripheral nerve lesion.

Complete loss of all the functions of a nerve indicates a severe lesion and is interpreted as a complete physiological interruption of that nerve.

Total paralysis of all the muscles supplied by a nerve distal to a lesion cannot alone be used as an indication of the severity of that lesion. Particularly is this true of the musculospiral nerve, slight injuries of which produce total paralysis.

Motion of segments about a joint does not indicate the integrity of the function of the nerve supplying the muscles ordinarily supposed to move such segments. The preservation of the function of muscles is largely determined through the examination of the movements of segments and not of the muscles themselves. The frequency with which more than one muscle may produce a similar movement of the segments about a joint makes this type of examination unreliable unless certain care be exercised.

The preservation of certain movements, the loss of which is supposed to follow particular nerve lesions, has been observed for many years. These movements may be caused by a number of factors; among which may be included, the anastomotic supply of muscles from adjacent nerves, movements produced by muscles other than primary movers in a particular action, movements occurring as a result of mechanical factors producing a change of direction of leverage by shortening and lengthening the tendons and muscles passing over several joints, and slight movements resulting from the recoil of elastic tissues following a movement in a direction opposite to the one desired. It is misinterpretation of such supplementary movements which lead to incorrect opinions that complete lesions are incomplete ones (Figs. 1, 2, 3, 4, and 5).

Our knowledge of the sensory changes following peripheral nerve lesions is in a chaotic state; partly because of the lack of standardized methods of examination but principally because of the lack of knowledge of the extent of the supplementary function of sensation of adjacent nerves.

It is well known that following a division of a mixed nerve, there is seen a certain area in which all sensation is lost surrounded by an area in which stimuli to pin prick and extreme degrees of temperature are felt. This area is known as the intermediate zone. The apparent sensory dissociation and the subsequent behavior of the two zones led to the

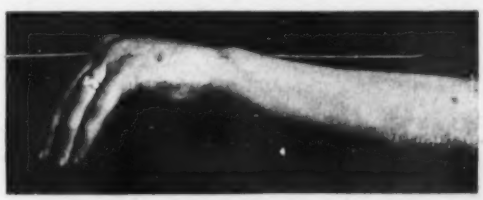


Fig. 3. Extension of wrist by supplementary movement of contraction of pronator radii teres.

Fig. 4. Opposition of the thumb by the adductor pollicis and flexor brevis pollicis in median nerve palsy.

Fig. 5. Adduction of the thumb by the extensor longus pollicis in ulnar palsy.

formulation by Head[1] and his co-workers of their theory that the sensory mechanism in the peripheral nerves consists of three systems: deep sensibility, protopathic sensibility, and epicritic sensibility. The sensibility to painful stimuli by pin prick which was present soon after an injury in that portion of the skin contained within the borders of the anatomic sensory distribution of a nerve was attributed by them to the function of overlapping adjacent nerves.

It is obvious that if any of the skin within the borders of the accepted anatomic sensory distribution of a nerve becomes sensitive to pin prick because of nerve overlap, it is necessary to determine to what extent this function can possibly develop, which can readily be done by determining the residual sensibility of a nerve. By this is meant that area of skin in which sensibility is preserved after all the nerves adjacent to the one being studied have been severed. For example, if we wish to determine the residual sensibility to pin prick of the radial nerve on the anterior surface of the hand, it is necessary to sever the remaining nerves which supply this area, namely, the musculocutaneous, ulnar, and median. What sensibility remains can be attributed only to the function of the radial nerve (Fig. 6).

From a large collection of similarly combined lesions found among over one thousand cases, I have been able to reconstruct the area of residual sensibility of a number of peripheral nerves. That portion of the residual sensibility of a nerve which extends into the recognized sensory distribution of an adjacent nerve is the overlap of the former on to the latter. Therefore, even if pain to pin prick be felt in this overlap area following an injury to such an adjacent nerve, it does not indicate a partial or recovering lesion. Only when sensation is present in the isolated supply of a nerve can the lesion be considered as a partial one. The area of the isolated supply to pin prick of various nerves is the area in which no overlapping occurs.

Corresponding to the area of the isolated supply of a nerve to pin prick is found analgesia to pinching, in my opinion an excellent indication of a severe nerve lesion.

Regarding the electrical changes demonstrated by the methods personally employed, namely, faradic, and galvanic stimulation, it may be said that complete reaction of degeneration is always present in a severe lesion but does not indicate an irreparable one. Of all the changes to electrical stimulation, the slowness of the muscular contraction is the only constant phenomenon which can be satisfactorily employed in determining the reaction of degeneration. Polar changes are inconstant and of course it may be expected the response to faradism would be absent frequently, even in partial lesions. Especially is this true of cases requiring more than 4 months for recovery. Although electrical examinations afforded no means whereby a differentiation between anatomical and physiological interruption could be made in the cases observed within a year following injury, it must be remembered that frequently after this period and always after a hundred

[1]Brain, 1905, xxviii. p. 111.

Fig. 6. Residual sensibility to pin prick of the radial nerve.

weeks, irreparable lesions show complete loss of response to any form of electrical stimulation.

The longitudinal reaction did not prove to be of any particular diagnostic or prognostic value. Of some interest was the fact that masses consisting of muscles supplied by nerves, severely and often irreparably injured, showed great increase of resistance to the continuous current. The constancy of this phenomenon unfortunately could not be controlled and its real significance therefore was not determined.

Rapid and extensive atrophy of the paralyzed muscles may be interpreted as meaning a severe lesion with a number of reservations. Ulnar nerve lesions as a rule show extensive atrophy whether severe or not. Atrophy is of service in denoting the severity of a lesion only when seen soon after injury. The amount of atrophy observed some months after injury is not commensurate with the severity of the lesion.

Measuring the amount of atrophy in the upper extremities distal to the elbow and in the lower distal to the knee, by water displacement, the following facts were found. As compared to the unaffected extremity the affected one showed in an irreparable ulnar nerve lesion, an atrophy of 4.5 per cent of the total mass, in recovering lesions 4.2 per cent; in radial nerve lesions there was an atrophy of 4.3 per cent in recovering lesions and 5 per cent in irreparable ones. In lesions of the median nerve, those recovering showed 11.2 per cent and irrecoverable ones 15 per cent atrophy; in sciatic nerve lesions recovering lesions showed 9.7 per cent and those irrecoverable 10 per cent; the external popliteal showed in the recovering lesions 6 per cent and in the irrecoverable ones 7.2 per cent atrophy.

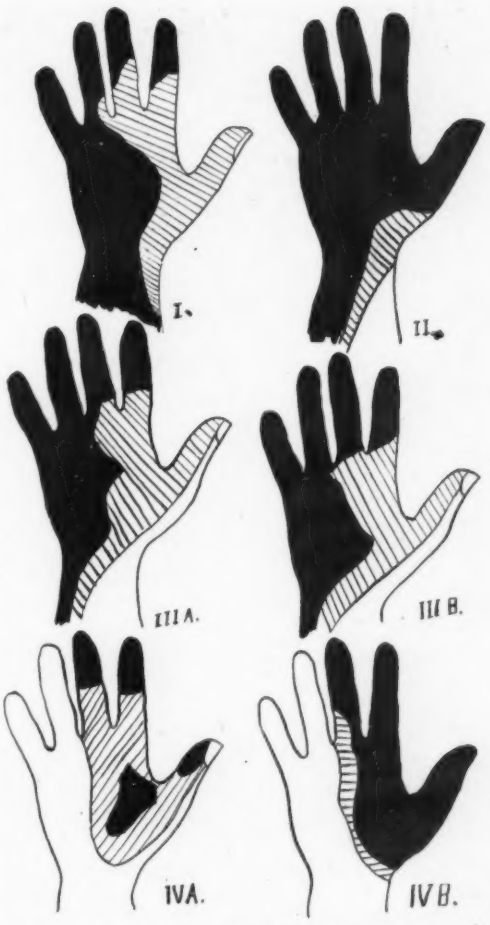


Fig. 7. *I*, Usual area in which sensibility to pin prick is preserved in combined lesions of ulnar and median nerves, or, in this instance, ulnar, median, and musculocutaneous.

II. Analgesia in the usual algesic area when the radial nerve is divided in addition to the ulnar and median.

IIIA. Preservation of sensibility to pin prick in a combined ulnar and median lesion. *B*. Resection and suture of these nerves did not produce analgesia of the algesic area.

IVA. Analgesia in a median nerve lesion, showing preservation of sensibility to pin prick over a large portion of the radial part of the palm. *B*. Complete analgesia of the radial part of the palm produced when in this case the superficial radial nerve was severed to be used as a cable transplant.

Although the percentage of loss of muscle mass was slightly greater in the severe, irrecoverable lesions. the difference was not

Fig. 8. Sign of complete recovery of musculospiral paralysis.

sufficient to be of diagnostic value. In addition to this, some irrecoverable sciatic nerve lesions showed but 1 per cent loss when a recovering showed a 17 per cent loss. In a recovering external popliteal nerve lesion we found 16 per cent and in an irrecoverable one only 1 per cent atrophy, etc.

In general it may be said that when observed some months after injury, absence of demonstrable atrophy is not an indication of a reparable lesion. It has impressed me that movement of the extremity, passive or active, is often responsible for an apparent lack of atrophy. How much any replacement of muscle by other tissue is responsible can only be conjectured.

Absence of pain, when the trunk of the nerve is subjected to pressure below the seat of the lesion, was demonstrable in many severe lesions, but quite a number of recoverable lesions showed this analgesia as well. On the other hand, not a few irrecoverable lesions showed the preservation of pain to such pressure. Only the ulnar, musculospiral, and external popliteal nerves are suitable for isolated pressure upon their trunks, and this only in those cases in which the injury is proximal to their superficial positions. The danger of producing pain by pressure upon adjacent structures is too great to make this a universally diagnostic phenomenon of certain value.

In agreement with Meige and Pitres[1] absence of any pain or pressure of the muscles which are paralyzed was found a very unreliable sign. In fact it was found that in a large number of cases, tenderness to pressure was more marked on the injured side and could probably be attributed in some cases, to the injury of other tissues; in others, to supplementary supply of sensation of the paralyzed muscle by adjacent nerves.

When tone was measured by a tonometer, it was found that only for a short time after an injury of a peripheral nerve, was the loss of tone any indication of the severity of the lesion. Even in such an instance the loss of the tone represented only a reflection of the general loss of function. The difference in millimeters of mercury was expressed in the ratio of from 160 to 180 in normal muscle to 40 to 60 in the paralyzed ones. In a very few weeks, infiltration, fibrosis, and other changes in the muscles and tendons vitiated what significance loss of tone might have.

Too little is known of the nature of trophic disturbances to enable us to employ them profitably in interpreting the severity of the lesion. Where protopathic sensibility was lost trophic ulcers were likely to occur. When an extremity was immobilized, growth of nails ceased. When an extremity was protected by a dressing hypertrichosis was at times observed. Generalized atrophy of the bones indicated only disuse. In other words the trophic disturbances can be employed as

[1]Rev. neurol., Par., 1906, April—May

an indication of the severity of the nerve lesion only when judged in the light of the presence of other conditions.

As to the absence of hyperæsthesia in the regions supplied by an injured nerve as an indication of complete interruption of that nerve, it can be stated definitely that as a matter of fact hyperæsthesia is not uncommon in just such cases, when sensation to pin prick has returned as the result of nerve overlap.

The signs of regeneration of a nerve are the manifestations of recovery of function. Among these are return of sensation, both subjective and objective, disappearance of reaction of degeneration, increase of tone, disappearance of atrophy and return of motion.

These manifestations differ in appearance and rate of return as to the pathology of the nerve and as to whether recovery is spontaneous or is consequent to surgical intervention. They are dependent upon the condition of the neuraxones. If descending degeneration has been slight or absent and the nerve recovers spontaneously and rapidly one type of course is followed; if resection and suture has been performed another type is observed. If little or no degeneration has followed, but a complete physiological interruption has existed for a long time, because perhaps of a constricting band, surgical relief of this morbidity is followed by a regeneration similar in character to that observed in lesions rapidly recovering spontaneously. If descending generation is severe or complete and conditions are such that the lesion recovers with no surgical interference, the course of recovery will be very similar to that observed following suture.

Rapidly and spontaneously recovering lesions showed two characteristics: First, in agreement with others (Sherren), I have found that such lesions do not show the dissociation of sensation previously referred to. Here little or no sensibility to pin prick returns before tactile sensation. Both forms of sensation are absent and return together. This in my opinion is due to the fact that the function of overlapping nerves is inaugurated only in the presence of a complete interruption whether it be physiological or anatomical.

Fig. 9. Pitres' test of recovered ulnar, at left; failure of test in ulnar palsy, at right.

From 200 peripheral nerve injuries which were incomplete and recovered soon after injury, only three were found where sensibility to pin prick was present and tactile sensibility absent. The return of sensibility to both pin prick and touch followed no definite rule as to its location but was in every instance patchy in character. Second, the return of function did not adhere to any definite rate of progression either as to sensation or motion and often all the muscles innervated by a nerve regained their function suddenly irrespective of their distance from the lesion.

Many cases of complete physiological interruption of a nerve showed their first sign of regeneration at such a time as one would expect it to occur were the nerve divided at the time of injury and sutured. From this time onward the regeneration progressed exactly as would a sutured nerve. It is reasonable to assume that in this type of severe lesion complete descending degeneration has occurred and conditions permitted the regeneration of the axones. Evidence of regeneration first appeared in from the eighth to ninth month, and it was noticeable that a considerable number of men wounded at about the same time, all began to improve together.

In my opinion this is additional evidence that very great conservatism should be exercised in making a decision for resection and suture in severe lesions of peripheral nerves not recovering within even 7 to 8 months.

The order in which the signs of regeneration appear have been given by Mme. Ath. Benisty[1] as follows: (1) Sensory regeneration, consisting of pain when the skin is pinched,

[1] The Treatment and Repair of Nerve Lesions. Military Medical Manuals, 1918.

Fig. 10. Inability completely to close the fist in median palsy.

pain when the nerve is pressed below the lesion, formication on pressure of the nerve and spontaneous aching in certain muscles; (2) arrest of atrophy and return of tonicity; (3) in some cases return of faradic contractility; (4) disappearance of objective sensory disturbances; and (5) voluntary movements.

As critical an examination of the clinical signs of nerve regeneration is necessary as was seen to be the case with the signs of complete physiological interruption of a nerve. In my experience return of pain upon pinching of the skin was many times the first sign of nerve regeneration, but very frequently was not. Only that return of pain to pinching which is found in such areas of skin as are outside the influence of nerve overlap, can be used as an indication of the recovery of a nerve. Frequently spontaneous aching and more frequently a sensation of a "different feeling" in an extremity preceded other signs of nerve regeneration. Pain upon pressure of the nerve trunk distal to the lesion was found unreliable.

Tinel's sign, or peripheral formication upon pressure or light percussion of the nerve trunk distal to the lesion, was found to be practically valueless. Where a nerve is superficial and pressure may be exerted upon it and it alone this sign might have some value. Unfortunately only few of the peripheral nerves have a superficial course and this only for a short distance. Elsewhere other structures may be included in the pressure. Where the sign is elicited by light percussion, the concentric waves of motion transmitted from the percussed spot may stimulate the nerve at a considerable distance.

In any event, of 50 cases of recovering lesions, 7 had complete absence of Tinel's sign and 8 had formication for only a short distance from the site of injury. Of 50 irreparable lesions, a complete Tinel's sign was obtained in more than 50 per cent of cases and only in 7 cases was it completely absent. If my technique be faulty, then I can only say that a method the success of which is dependent upon uncertain physical conditions which are poorly controlled, a method which requires a refinement of technique obtained only by a favored few is productive of an unreliable clinical sign in the hands of the standard observer.

Arrest of atrophy and return of tonicity were not profitably employed in those cases recovering some months after injury for reasons already stated.

The electrical phenomena of regeneration of nerves were observed only in those cases recovering more than 5 months after injury. They were not sufficiently critically studied to permit us to use the results obtained in judging the reliability of current views. It may be well to state, however, that in the partial lesions which showed beginning recovery before the eighth month following injury, a response to faradism at times returned before motion. At times motion was present and faradic response absent. The cases showing beginning regeneration following resection and suture, performed not less than 6 months following injury, never showed any return of response to faradism before the return of motion. The same is true of the cases showing beginning spontaneous regeneration only 8 months or more after the injury.

It has been noted by most observers that sensation to pin prick and extreme degrees of temperature (protopathic sensibility) returns long before tactile sensibility and before motor function. This return of sensation to pin prick in the anatomic sensory distribution of a nerve, which occurs some time, i.e. more than 43 days, following injury, was attributed by Head and his co-workers to be due to the early regeneration of protopathic fibers.

Fig. 11. Closure of fist in recovered median palsy.

Fig. 12. Closure of fist in recovered median palsy.

The length of the nerve to be regenerated made no difference as to the time of the first appearance of sensibility to pain.

Such a lawless regeneration appears to me to be short of the miraculous. I maintain that the return of sensibility to pin prick, which occurs before the return of sensibility to touch, is present only in regions which occupy the areas of nerve overlap, and that this return of sensibility to pin prick cannot be interpreted as a sign of nerve regeneration. I am supported in this view by the facts that I have never found a return of sensibility to pain, when sensibility to touch has not returned, except in an area of overlap (Fig. 7, *I*); that when a nerve is divided and at the same time one or more adjacent nerves are divided, sensation to pin prick does not return in the area of overlap of these nerves even many months following injury (Fig. 7, *II*); that when a nerve adjacent to one that is severed and which supplies an area of overlap to that nerve is sectioned, the pre-existing sensibility to pin prick in the overlap area is lost (Fig. 7, *IVA*, *IVB*); that when sensibility to pin prick is present within the anatomic sensory distribution of a severed nerve, resection and suture has no effect upon the general outline of this area of sensibility (Fig. 7, *IIIA*, *IIIB*).

Only when that portion of the area representing the anatomic sensory supply of an injured nerve, removed from the influence of overlap, in other words its isolated supply, becomes sensitive, can we say that regeneration is present. Under this condition at no time did protopathic sensibility return before epicritic. When sensation returned, it became evident in patches scattered over the heretofore analgesic zone and not only upon the borders of this zone. Likewise under this condition, only once in 67 cases of complete physiological interruption of a nerve recovering following surgical treatment, did sensation return before motion.

In the interpretation of the significance of return of motion relative to regeneration, proper recognition must be made of supplementary motility. So great does this influence the movement of some segments that I have never been able definitely to state that such movements as I have observed return following resection and suture of the ulnar nerve, were due unquestionably to nerve regeneration, with the exception of a distinct contraction of the flexor carpi ulnaris. These movements are likewise very confusing in median nerve lesions. Some of the movements which cannot be supplemented in the various nerve lesions are:

In musculospiral lesions, extension of the proximal phalanx of the thumb and abduction of the thumb in the plane of the palm, and extension (not alone tension) of the proximal phalanges of the fingers. In ulnar nerve lesions, flexion of the proximal phalanges of the ring and little fingers with the distal phalanges extended, and lateral movements of the extended middle finger. In median nerve lesions, flexion of the distal phalanx of the index finger and of the thumb. In combined lesions of the ulnar and median nerves, all movements of the hand except flexion at the wrist and hollowing of the hand. In external popliteal lesions, eversion of the foot.

Some signs of complete motor recovery are of value: in the musculospiral nerve, placing

the little finger on the seam of the trousers with the fingers well extended and with the palm turned to the front, is a sign suggested by Pitres[1] (Fig. 8).

In ulnar nerve lesions, he suggests that the palm be placed flat upon a table with the fingers apart, then the middle finger should be moved inward and outward and finally the table scratched with the nail of the little finger without moving the wrist (Fig. 9). In median nerve lesions Claude[2] suggests the clenching of the fist with all the fingers well flexed into the palm and with the distal phalanx of the thumb firmly pressed upon the dorsal aspect of the second phalanx of the middle finger (Figs. 10, 11, and 12).

It has been observed by Mme. Ath. Benisty[3] that in individual nerves, certain muscles recover motility in a definite order.

In a general way the cases recovering spontaneously showed this individual characteristic in our experience. In musculospiral lesions the extensors of the wrist were the first to recover, followed by the extensors of the fingers, then the abductor and extensor of the thumb. In ulnar nerve lesions the intrinsic muscles of the hand were the last to recover. In median nerve lesions, the muscles of the thenar eminence and the flexor of the index finger were the last to recover. In external popliteal lesions the extensors of the toes and in sciatic nerve lesions the tibialis posticus and the flexors and extensors of the toes were the last to recover.

Cases recovering following primary and secondary suture did not always adhere to a definite rule. Of these I observed only 39 cases and among them the following muscles showed the first return in the various lesions: In musculospiral lesions following primary sutures the extensors of the wrist, the extensor communis digitorum and abductor pollicis, followed by the extensor longus pollicis, following secondary suture, extensors of wrist, followed by the extensors of the fingers, then the thumb. In median nerve lesions following secondary suture, the pronator radii teres, the palmaris longus, and flexor carpi radialis were the first to recover. The supplementary movement in ulnar nerve lesions was so extensive that it was not profitable to attempt to determine what muscle regained its function first. In combined lesions of the ulnar and median nerves, the flexor carpi ulnaris, flexor longus pollicis, and flexor sublimus digitorum were the first muscles to functionate following secondary suture. In the external popliteal nerve the peronei, tibialis anticus, extensor longus digitorum, and extensor hallucis were the muscles to recover first, in the order named, following primary suture. Following secondary suture the tibialis anticus and extensor longus digitorum returned first. In the sciatic nerve, following primary suture, the peronei and the extensor longus digitorum were the first to recover. Following secondary suture the gastrocnemius and tibialis posticus were the first to recover.

Following primary suture the first return of motion was observed in 6 months in musculospiral lesions. The first return of motion in external popliteal cases was observed 7 months, and in sciatic nerve lesions 6½ months, following primary suture. In musculospiral lesions following secondary sutures, the first return of function occurred from 5 to 6 months after suture. In secondary sutures of the sciatic nerve the first return of function was apparent in 6½ months. In external popliteal nerves the first return of function occurred in 8 months following suture. In a combined ulnar and median nerve lesion, muscles innervated by both nerves showed return of function in a little over 6 months following secondary suture.

Of all the signs of regeneration of a nerve, I consider the disappearance of the reaction of degeneration, the return of objective sensibility in the isolated supply of a peripheral nerve, and the return of motion, as the only certain ones. The sensory and motor signs are the only constant ones. The other signs which have been mentioned are suggestive but not positive. The only objective sensory phenomenon which precedes the return of motion is pain on pinching in the isolated supply of the nerve. Sensibility to pain and touch return at the same time.

[1]Rev. Neurol, 1916, April-May, p. 486.
[2]Quoted by Benisty. Clinical Forms of Nerve Lesions.
[3]Loc. cit.

CERVICAL RIBS

With Presentation of Cases and a Bibliography

By JAMES A. HONEIJ, M.D., New Haven, Connecticut

CERVICAL ribs present two interesting groups of cases: those that have all the symptoms associated with this condition and yet have no cervical ribs and those that give no symptoms and on examination prove to have cervical ribs.

After reviewing the enormous literature on the subject and especially after reading Keen's and also Streissler's very excellent articles, little remains to be said. The subject, however, is still interesting, and because of a rather large and varied group of cases with and without cervical ribs, an added report did not seem wholly unwarranted.

In reviewing the literature, one is struck by much contradictory evidence; statements are made regarding the common occurrence and also the variety of cervical ribs, of the lack of and the numerous symptoms, the difficulty and also the ease of diagnosis, of the worth and uselessness of radiographic diagnosis. Some authors believe cervical ribs occur more commonly bilaterally. Very few make the distinction between true cervical ribs and normal transverse processes and all the intermediary conditions between these. There has obviously been a lack of study of individual cases and a lack of understanding of the development of supernumerary or rudimentary ribs.

In studying a group of negative cervical rib cases with positive symptoms, I was rewarded by finding large, irregular transverse processes of the seventh cervical vertebra with a very narrow space between it and the first thoracic rib, which could very naturally cause all the symptoms of which the patients complain. The reverse is equally true. To prove this statement, cases of true cervical ribs were found where the costal space was so wide that pressure on nerves and blood vessels was improbable and consequently could not give rise to symptoms. Cases with curvature of the spine with relatively insignificant pressure, transverse processes or rudimentary ribs can, on the other hand, give rise to very severe symptoms. There is apparently a lack of appreciation of the many factors which produce symptoms and a limited point of view in considering true cervical ribs.

In a review of the literature to determine the most common symptoms for comparison with the cases reported here, it was interesting but impossible to tabulate the enormous variety and combination of symptoms. They divide themselves naturally into circulatory and nerve conditions and into muscular and other secondary symptoms. Keen gives an excellent division of symptoms as follows:

1. Local symptoms: tumor, pain on pressure, bruit, etc.
2. Nervous symptoms more frequent than vascular.
3. Vascular symptoms: pulsations, ischæmia, gangrene, œdema, thrombosis, aneurism.
4. Muscular symptoms: wasting, loss of power, easily tired, dysphagia. Scoliosis.

Cases have been reported with symptoms resembling Pott's disease, Raynaud's disease, hyperthyroidism, aneurism, and others as a cause of Klumpke-Déjerine's paralysis; a larger number of cases have been reported with various forms of neuritis than with vascular disturbances; many cases with trophic and vasomotor affections; others with muscular atrophy and sensory disturbances and again others with only atrophy of the hand muscles. In a few cases, there was definite dilatation of the subclavian vessels and one case was reported giving rise to a spasm of the diaphragm. Gangrene as an end-result of various preceding disturbances is not uncommon. In two cases, cervical rib had an etiology of hereditary syphilis. Since the symptoms in cervical ribs may vary from the slightest nerve, vascular, or muscular symptoms to the

Fig. 1.

Fig. 1a.

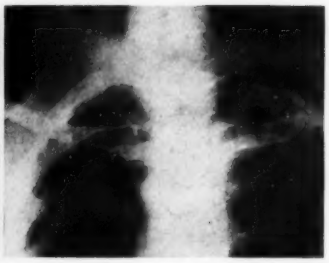


Fig. 2.

Fig. 1. Case XX. Female. History not known. Normal symmetrical thorax. Roentgenograph shows a completely developed seventh cervical rib on the right fused with first dorsal rib. On the left the transverse process of the seventh cervical rib shows a small rudimentary tubercle.

Fig. 1a. Case 3446. B., male, age 32. October, 1919. No symptoms due to cervical ribs. Question of pulmonary tuberculosis. Roentgenograph shows typical bilateral seventh cervical ribs, most prominent on the left.

Fig. 2. Case 3025. C., male, age 26. Private M. C. No symptoms, no history. X-ray examination shows some diffuse peribronchial thickening. Thorax is asymmetrical. Complete cervical rib on right, one-half the size of the first thoracic rib. There is a small rudimentary rib on the left.

most severe changes, and since the diagnosis of cervical ribs from symptoms alone may be confused with various diseases, it is obvious, therefore, that there are no definite symptoms or group of symptoms positive of cervical ribs. And, as has already been pointed out, symptoms resembling those that are found in cervical ribs, frequently occur without other evidence of cervical ribs. It is interesting, however, to consider what conditions may cause symptoms which may be mistaken for cervical rib.

a. Results from disease or traumatism: pulmonary apical tuberculosis. Callus formation from fracture of the first thoracic rib, clavicle.

b. Tumor growths: glands, aneurism, enlarged thyroid.

c. Scoliosis, unilateral compression.

d. Abnormalities: First thoracic rib. Clavicle.

e. Inflammatory conditions: transitory torticolis; of shoulder-joint; neuritis (occupational).

f. Exostosis of transverse processes. Scalene attachment. Localized myositis ossificans.

Scoliosis is frequently mentioned in connection with this condition (Schoenebeck), but the effort to determine whether an increasing scoliosis was the cause of symptoms where there were prominent transverse processes or even cervical ribs, or whether cervical ribs gave rise to a scoliosis, met without success.

Another interesting and not uncommon point is that after operation severe scar-tissue formation has often resulted, which has given rise to all the previous symptoms of cervical ribs and, in some cases, these symptoms were more severe after operation than before. There is still another interesting factor in the production of symptoms. The frequency of accidents as a cause is abundantly reported which is also apparent in the cases reported here. Muscular effort, bony compression, inflammation, and in elderly individuals, change in posture with forward or lateral bending of the vertebral column associated with tissue changes, may all give rise to symptoms with either cervical ribs or enlarged transverse processes present. These last factors are far more commonly associated with cervical ribs than the spontaneous occurrence of symptoms. This opinion is based on the review of the literature between the years 1894 and 1918, which gives approximately 200 cases in 152 articles as well as on the cases here reported. The number of cases reported during this period is far greater than all those reported up to 1894. Pilling collected cases totaling 139. In most of these cases the cervical ribs were found on postmortem examination.

Fig. 3.

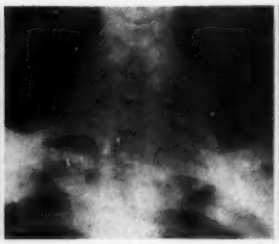


Fig. 4.

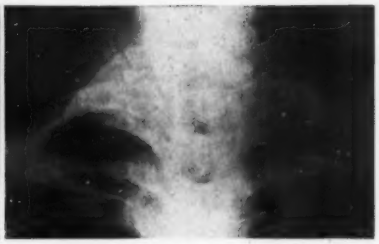


Fig. 5.

Fig. 3. W. C. No. 5, male, age 32. Medical student. The lungs show some peribronchial thickening. Considerable markings at both apices. Slightly greater density of left apex. Hilus on right enlarged and increased in density. Cervical rib on right. Questionable tuberculosis.

Fig. 4. Case 1453, female, age 27. Clinical diagnosis: question of pulmonary tuberculosis. No symptoms or evidence of cervical rib. X-ray examination showed complete seventh cervical rib on the left side, rudimentary rib on the right side.

Fig. 5. O. E. S. No. B315. Male, age 26(?), second lieutenant, Quartermaster's Corps. Thorax symmetrical.

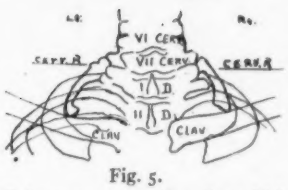


Fig. 5.

Diagnosis: Pulmonary congestion; bronchitis; questionable light bronchopneumonia, left base; pleural diaphragmatic adhesions; cervical ribs.

Most cases are reported as being between the ages of 20 and 30 years. Streissler's table of age incidence is as follows:

Years	Cases	Percentage
0 to 10	11	7.7
11 to 20	46	32.2
21 to 30	43	30.0
31 to 40	19	13.3
41 to 50	16	11.2
51 to 60	6	4.2
61 to 70	1	0.7
Over 70	1	0.7
	143	100

Age is of little importance in diagnosing the condition unless the associated lesion and cause of the occurrence of symptoms are added.

Cervical ribs occur more commonly in females, but here again is a divergence of opinion as to the exact ratio. Streissler in 200 cases found women affected in 70.8 per cent and men in 29.2 per cent. Church says between 60 and 70 per cent occur in females. Keen reported that in 41 cases, it occurred 75.6 per cent in females and 24.4 per cent in males. In another group of 19 cases, 11 were in females and 8 were in males. In the group reported here 12 are women and 9 men. In the rib anomaly cases reported here, the condition (see List No. 4) was found only in males, but I do not mean that such anomalies do not occur in females; it occurs, however, more frequently in males.

Authors are all agreed that cervical ribs occur more commonly bilaterally. It is difficult to determine, however, from the literature whether the condition was the same on both sides. From cases observed here (see tracings), the same changes are rarely seen on both sides, and the fact that symptoms occur more commonly unilaterally indicates a revision of this positive assertion. Pilling and also Tilmann reported 67 per cent as occurring bilaterally and 33 per cent unilaterally. Miller states that they occur bilaterally in 80 per cent of cases. Keen states that up to 1894, it was believed to occur bilaterally in two-thirds of the cases. If true cervical ribs are considered and are included with rudimentary tubercles or prominent processes, then the figures may be correct, but, if true cervical ribs alone are included, then undoubtedly an error is made. The symptoms are unilateral in 95 per cent of cases, and more commonly on the ~~left~~ right. This has not been explained.

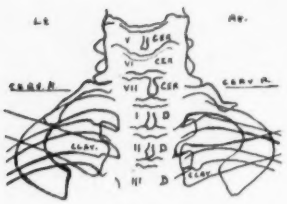
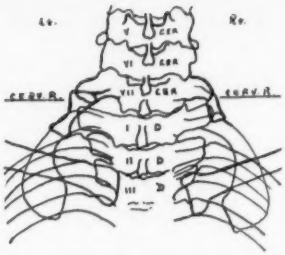


Fig. 6.



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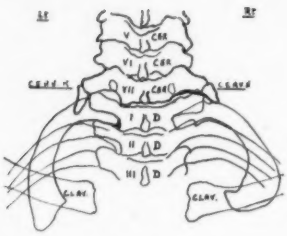

Fig. 8.

Fig. 6. V. L. Case 4027, female; age 40; occupation, housewife. The patient was born in Italy, is married and has had fourteen children. Two died from causes unknown. The other twelve are healthy. Eighteen months ago the patient suffered pain in the right shoulder radiating to the fingers. She also had pain in the right knee, dull aching in character, which she calls "rheumatism." Fifteen years ago the patient had an operation on the right side of the neck, which was probably for glands.

Fig. 7. Case 2144. A. R., male, age 27. May, 1918. The patient had pain in the left leg, duration 2 weeks. There was numbness and the leg was cold, and these symptoms were worse in damp weather. A hard nodular tumor is felt in the right cervical region. The patient complains of slight pain in this region at times.

Fig. 8. Case 1033. J. C., male, age 21. February, 1916. About 3 months ago, while at work, the patient felt a tingling sensation through the extremities and body. The extremities were cyanosed and cold. The feet were swollen at first. There was numbness in the region of the heart. A high arched, abnormal protuberance can be felt on each side of the cervical spine. The thyroid is rather enlarged.

To appreciate more fully the origin of cervical ribs attention is drawn to the embryonic and developmental considerations of this condition (Fig. 17).

Keen states very briefly that a cervical rib is only an abnormal deviation of a normal portion of a vertebra. We are apt to forget, he says, that in the cervical, the lumbar, and even in the sacral region there exists a representation of that which in the dorsal region is fully developed into a normal rib. It is well known that there are greater variations in the last three thoracic ribs and in the transverse processes of the lumbar region than there are in the cervical region. Therefore it has been thought that the law of compensation plays a part, so that broadly speaking when the twelfth thoracic ribs are absent seventh cervical ribs are provided. Unfortunately, although there are some interesting cases of variation and compensation, the exception to the rule is frequently found. Capitan, Todd, and others have been interested in determining what the cause is of these supernumerary ribs and what factors play a part in their production. From a purely evolutionary point of view, cervical ribs are of some significance.

Tredgold believes that additional ribs are due to the persistence of a former condition and that a decrease is simply a part of that steady progressive change which has been seen to run right through the order. Therefore, it is seen that a gradual but marked reduction takes place in the total number of ribs as we rise in the animal scale. To bear this out, Tredgold published tables of other investigators which show that, for instance in man, the eleventh and twelfth thoracic ribs are frequently rudimentary. In

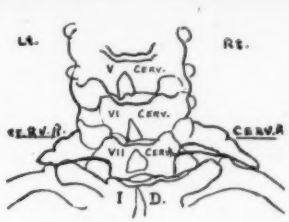

Fig. 9.

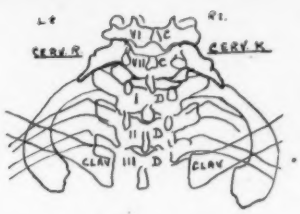

Fig. 10.

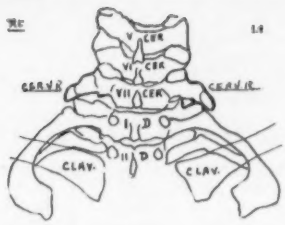

Fig. 11.

Fig. 9. Case 205. C. F.; age 24; occupation, driver. June, 1914. One week ago while wrestling with a man weighing 175 pounds, the opponent fell on him doubling his neck forward until there was a sharp crack. Since then he has been able to move the neck but very slightly. Roentgen diagnosis: cervical rib on both sides.

Fig. 10. Case 1295. J. W., female, age 18. The symptoms and details of the case are not known. Roentgen diagnosis: rudimentary seventh cervical rib.

Fig. 11. Case 597. D. S., female, age 32. March, 1915. The patient complains of numbness in the tips of the three lateral digits of the right hand. In March, 1916, the patient was operated upon for cervical rib on the right side. The rib was removed and later pain and paralysis appeared. In March, 1917, the patient was operated upon for sarcoma in the right axilla. A tumor was found under the pectoral muscle extending into the axilla. At that time there was complete paralysis of the right upper exremity.

the chimpanzee the twelfth and thirteenth are poorly developed and in the lemur the thirteenth to the sixteenth which is the last rib, are poorly developed. Capitan points out that birds like ostriches have cervical ribs and that the dolphin and porpoise have developed cervical ribs with projections articulating with the first thoracic rib. It is interesting to note, therefore, that in man the embryo has 29 pairs of rudimentary ribs and that consequently 17 pairs disappear before birth. All the cervical vertebræ naturally then have rudimentary ribs and it is the seventh cervical rib which is the last to disappear in fœtal life. If we start to reason from this point we are face to face with the fact that here something happens to prevent the retrogressive changes from taking place. Todd believes that it is an interference in absorption but also that the disappearance of the seventh cervical rib may be due to pressure of nerves and consequently atrophy of the compressed tissue. Todd also states that the vessels have equal importance with the nerves as causative factors in those modifications of the upper end of the thorax which are represented by the pressure of rudimentary ribs. This, however, would not account for the disappearance of the fifth and sixth cervical ribs. We know, of course, that the rudimentary rib is grooved for artery and nerve, and, as Todd points out, this is most marked in fœtus and in cervical ribs, least apparent in the adult and in an intermediate condition in the child.

Dwight suggested that the principle underlying these variations is the movement of the whole thorax upward or downward on the vertebral column.

Capitan reiterates that it is merely a progressive evolution, pointing out that the thorax is reduced at its two extremities. Cervical ribs, therefore, may occur on both sides and cases have been reported as high as the third cervical rib. The ribs themselves may be *reduced* to mere tubercles on the

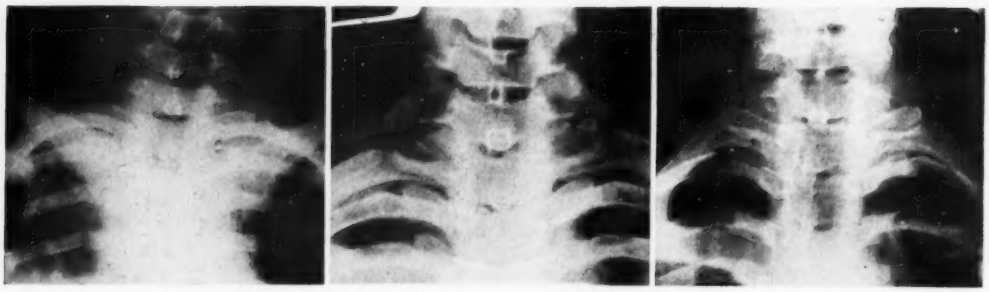

Fig. 12.

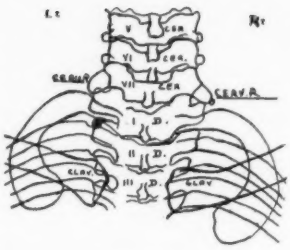

Fig. 13.

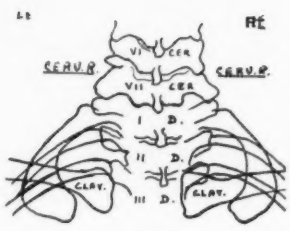

Fig. 14.

Fig. 12. Case 3595. M. D'A., female; age, 30; occupation, housewife. August, 1919. Clinical diagnosis: polyarthritis, hydrothorax, etc. No symptoms of cervical ribs. X-ray diagnosis: the seventh cervical vertebra shows rudimentary cervical ribs, bilateral.

Fig. 13. Case 1502. I. G., female; age 32; occupation, housewife. January 5, 1917. There was pain in the left forearm which had been present two weeks. She gave no history of injury except that she struck her thumb a month ago. A large mass resembling a tip of a cervical rib was felt in the supraclavicular space. Pressure at this point accentuated pain down the arm.

Fig. 14. Case 1952. C. M., female; age 31; occupation, housewife. February 29, 1912. The patient complains of numbness and tingling in the left hand, which she has had since last October. She has had the same sensation in the right hand but it has not been as severe as in the left hand.

transverse process, or there may be distinct *hypertrophy* of the transverse processes. In conclusion, therefore, the evidence as to cause and influencing factors has not been convincingly presented from a point of view of histology and a very interesting problem lies before the student.

The cases presented here have been divided into two classes: those that may be considered true cervical ribs, articulating as do the thoracic ribs with the transverse processes and those that may be considered rudimentary only. These are seen in Lists Nos. 1 and 2.

Although Gruber's classification of cervical ribs is apparently well known, there is little indication in the literature to show that it has been followed. Gruber divides cervical ribs into four classes, mainly according to size and therefore growth, as follows:

Class 1. Consists only of a node, which does not extend beyond the lateral dimensions of the transverse processes of the vertebræ.

Class 2. A blunt projection of bone 4 to 5 centimeters in length.

Class 3. A rib which extends far enough forward to articulate with the first rib or even to be attached to the sternum by a ligamentous band.

Class 4. A complete rib having vertebral origin and costosternal cartilage.

LIST NO. 1.—CERVICAL RIBS

1. W. C. Case No. 5. Typical seventh cervical rib on right, approximately one-half the width of first thoracic rib and extending forward one-half its length.

2. O. E. S. Case No. B. 315. Typical seventh cervical ribs, of same size and length on both sides, approximately one-half the size and length of first thoracic rib.

3. V. L. Case No. 427. Typical seventh cervical ribs on both sides, approximately one-third the length and size of first thoracic rib. The right differs from the left.

4. A. R. Case No. 2144. Poorly developed seventh cervical ribs on both sides, the right is not as well developed as the left.

5. J. C. Case No. 1033. Poorly developed seventh cervical ribs on both sides.

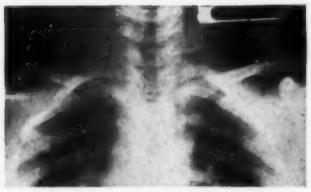

Fig. 15. Case 3400. S. R., age 9; female; occupation, school girl. August 28, 1919. No clinical diagnosis. The patient has had a cough since April, 1919. Three days ago she began to have a headache and pain in the left side, with numerous moist râles at both bases. Diagnosis: acute bronchitis. X-ray examination: The transverse processes of the seventh cervical vertebra are unusually prominent. They project at right angles. At the end of each transverse process there is a small rudimentary rib. Do not give rise to any symptoms at present.

6. XX. Complete seventh cervical rib on the right, as well developed as the first thoracic rib. A small bony tubercle on the left.

7. F. Case No. 1453. Complete seventh cervical rib on left. A rudimentary seventh cervical rib on right.

8. C. Case No. 3025. Complete seventh cervical rib on right. A small rudimentary rib on left.

9. B. Case No. 3446. Complete bilateral seventh cervical rib. On left sternal articulation. On right unusual articulation.

LIST NO. 2.—RUDIMENTARY SEVENTH CERVICAL RIBS, TUBERCLE FORMATION

1. I. G. Case No. 1502. Shows a small bony tubercle on right transverse process, seventh cervical vertebra. Transverse process on left is prominent.

2. C. F. Case No. 205. Very large bony outgrowths both sides on transverse process of seventh cervical vertebra.

3. D. Case No. 4167. Sharp bony outgrowths both transverse processes, seventh cervical vertebra.

4. D. Z. Case No. 1103. Many small irregular bony outgrowths on transverse processes seventh cervical vertebra.

5. M.D'A. Case No. 3595. Rather marked bony outgrowths on transverse processes seventh cervical vertebra.

6. J. S. Case No. 1212. Small bony tubercle on right transverse process, seventh cervical vertebra. Transverse process large on left.

7. D'S. Case No. 597. Prominent bony outgrowths on transverse processes of seventh cervical vertebra.

8. J. W. Case No. 1294. Well-marked bilateral outgrowths articulated on right, seventh cervical transverse process.

9. S. R. Case 3400. Bilateral prominent outgrowths on seventh cervical transverse process.

10. E. St. J. Case No. 3751. Small outgrowths on both transverse processes of seventh cervical vertebra.

Fig. 16. Case 469. S. R. V., male, age 26 (?). July 14, 1919. Diagnosis: pulmonary tuberculosis. There were no symptoms suggestive of cervical ribs. The roentgenograph shows the first rib on the right to be approximately the same length as the left first rib, but its width is much less, being 0.7 centimeters on right and 1.3 centimeters on the left. There is a fusion of the distal end of the first to the second rib in the midclavicular line. There is slight asymmetry of thorax.

11. P. Case No. 3826. Rudimentary ribs, both sides, seventh cervical vertebra. Left more prominent, approximately 1.5 centimeter; right 1 centimeter. Definite outgrowths from transverse processes not articulated. Questionable pulmonary tuberculosis—no symptoms.

12. O'C. C. Case No. 3781. Rudimentary tubercle 0. 5 centimeter left transverse process seventh cervical vertebra. Right transverse process prominent. Space on left considerably narrowed. Patient with bone syphilis with diagnosis also of questionable cervical Pott's. No symptoms.

If a division is made of the cases described here according to Gruber's classification we have the following results: in Class 1, 8 cases; in Class 2, 4 cases; in Class 3, 5 cases; in Class 4, 4 cases.

In List No. 1, 9 cases of cervical ribs are given. In one case a positive diagnosis was made. In 3 of the cases there were no indications or symptoms of cervical ribs even after this condition had been determined. In the remaining 5 cases the diagnosis had not been made, although some of the symptoms referred to the cervical region. In 3 of the cases there was also a diagnosis of questionable pulmonary tuberculosis. In two of the cases, Nos. 3025 and 1453, the question of it being a rudimentary first thoracic rib was debated for a considerable time. This bears out the statement of the difficulties encountered in making a differential diagnosis between a cervical and a first thoracic rib; for comparison a case of rudimentary first thoracic rib is shown, Case No. 469. If the thorax is long, narrow and the apices

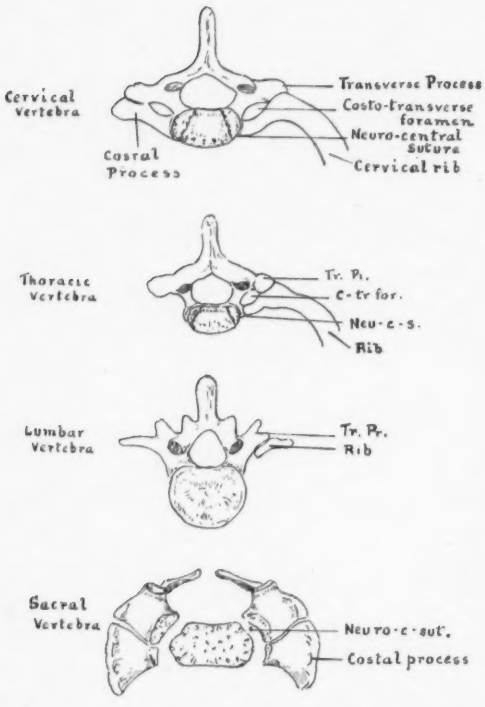

Fig 17. Morphology of the transverse and articular processes (*Morris*).

"The sixth, seventh, and possibly other cervical vertebræ present an additional center on each side of the neural arch for the costal process; it appears before birth . . . The costal processes of the seventh cervical not infrequently fail to ankylose with the vertebra; when this is the case, the processes become cervical ribs. Sometimes these ribs are of large size." (Henry Morris.—*Human Anatomy*. 1893, p. 38.)

arched and also if the thorax is asymmetrical the diagnosis becomes the more difficult.

Among the 12 cases of rudimentary cervical ribs, List No. 2, various stages of development are shown. Two cases are of especial interest. The first, Case No. 597, was operated on and the rib removed. It is unlikely, in view of the facts as presented today, that the processes could have caused the symptoms thought to be due to pressure on the nerves by the seventh cervical ribs. The case proved to be one of malignant disease, the tumor mass being in the right axilla, exerting pressure on the brachial plexus. Operation on the cervical region did not relieve the symptoms and subsequent examination revealed the sarcoma. This is presented to demonstrate again the difficulties of diagnosis. Three cases gave a history of tingling sensation in left hand and numbness, but no diagnosis of cervical rib was made or was justified.

In two cases, a cervical rib was suspected and in one of these cases the hands were cold and blue as far as the wrist, with lack of sensation. The patient was 14 years of age and gave no history of trauma.

In one case a history of trauma was given. The patient, a man of 24, was injured while wrestling. An injury to the shoulder was suspected but radiological examination showed it as being within normal limits.

In the last 5 cases of the series there were no symptoms, the condition being found on examination of the lungs in 4 cases and of the vertebral column in the other.

These cases are more interesting from a point of view of symptoms, because it is difficult to determine whether the degree of growth is sufficient to produce pressure symptoms. Case No. 1103 shows no evidence of cervical rib, but there are numerous small exostoses indicating an inflammatory condition, which may be grouped under conditions of scalene exostosis and without doubt are sufficient to produce symptoms likely to be considered as caused by cervical rib. Then in this group there are cases with projecting processes or transverse processes that may easily give rise to symptoms in case of injury. The spaces between seventh cervical and first dorsal being considerably decreased, any inflammatory reaction in that vicinity would cause sufficient pressure to give rise to cervical rib symptoms.

Among the 17 cases presented in List No. 3 under suspicion of having cervical ribs, cases with more or less typical symptoms and history, no evidence was presented on radiological examination of such a condition existing. Two of these cases are given, to illustrate more fully the type of history given and symptoms which are considered as probably due to cervical ribs.

CASE 1. C. R. No. 3127; female; age 19; occupation, school girl. Physical diagnosis: Cervical ribs. Complaint: Painful, swollen, discolored left arm.

Fig. 18. Anatomical specimen of seventh cervical ribs.

Present illness: Onset since birth. The patient has had attacks as follows: She will go to bed feeling good and apparently healthy and in the morning awake complaining of throbbing pain, steady and dull in character, beginning in left arm and running down the arm to the forearm and fingers but not radiating to shoulder. The arm cannot be moved or flexed at the elbow; the swelling is most marked below the elbow but to some extent in the arm and shoulder. The arm is very tender and discolored to some extent all the time but more marked during an attack. These attacks come about 1 to 2 months apart, last 7 to 10 days and then the arm appears normal, without pain and with slight discoloration. During bad weather the attacks come oftener and are somewhat worse. The patient feels well and healthy except for these attacks and some pain in lumbar region. The pain in back has been worse the last six months. Ordinarily the patient is not nervous but has noted that she is much more nervous during attacks.

Past history. These attacks as described have occurred since birth. The patient has had rheumatic fever. She was very delicate as a child, has had a good many attacks of sore throat and tonsillitis. She has not suffered from arthritis. She has had some form of "heart trouble."

The patient's mother was diabetic, and at present is not very well. The father is alive and well. Two sisters and two brothers are alive and well. One sister died 10 years ago of chorea or rheumatic fever. Two sisters died in infancy. The family history reveals no tuberculosis, heart trouble, or kidney trouble.

Physical examination. The left upper extremity is held in semi-flexed position. There is no muscular atrophy. There is present marked varicosity from shoulder-joint to wrist. The elbow-joint is rather prominent and the forearm is bent slightly outward. The color is dusty and cooler to touch than normal. Active and passive movements are limited but possible, and normal extension is possible with some difficulty and pain. The skin of arm is very sensitive to touch and pressure produces pain.

The blood examination was negative. The urine examination was negative. X-ray examination reveals no evidence of cervical rib, although the transverse process of the seventh cervical is slightly more prominent than usual, especially on the right.

CASE 2. A. C. L., No. 470D, male, age 42. February, 1915. Complaint: has no use of right forearm. The patient first noticed trouble in his right hand in 1914. The weakness and pain in the hand and wrist were accompanied with prickly feeling in all the fingers. In June the patient placed the weight of his body on the right wrist which gave way causing pain. Since then pain has extended throughout the whole upper extremity which has grown weak and thin. Now he has pain in his right shoulder and when attempting to lift the arm there are creaks heard in the shoulder-joint. Nine years ago the patient dislocated the right shoulder. He complains also of cramps in the right leg.

Physical examination. The middle portion of right trapezius muscle measures less than the left. The deltoid is firm but small. The biceps are firm but small. The forearm feels cool. The grip is weak. No pain is present in the nerve trunks. Incomplete wrist-drop is noticed. He cannot lift his hand to the horizontal. There is atrophy of the hand. The thenar and hypothenar areas are not much affected. There is slight spasticity of the right forearm. Pain is produced on deep pressure of the fourth to sixth dorsal spines. Knee-jerks are increased on right. There is a tendency to ankle clonus on the right.

Subsequent history, February 8, 1915. The patient noticed tingling and numbness involving the right side of the face and the right side of the neck and shoulders, also the right arm. Three weeks later he noticed weakness of the right arm and hand. Pain was also present in the triceps muscle especially after work. The pain was continuous, worse at night, and increased on motion.

X-ray examination reveals no evidence of cervical ribs.

LIST NO. 3.—NEGATIVE CASES

Histories given with typical symptoms suggesting cervical rib.

1. V. E. Case No. 1119. Negative seventh cervical vertebra. Question, however, of transverse processes of sixth cervical vertebra.

2. H. A. Case No. 1605. Somewhat prominent transverse processes especially on right, of the seventh cervical vertebra.

3. I. D. Case No. 1958. Fairly prominent transverse processes seventh cervical vertebra.

4. J. C. Case No. 1926. Slight prominent transverse processes seventh cervical vertebra.

5. J. S. Case No. 939. Broad and slightly prominent transverse processes seventh cervical vertebra.

6. H. M. Case No. 2560. Prominent transverse processes seventh cervical vertebra.

7. C. D. Case No. 1763. Transverse processes seventh cervical vertebra unusually long especially on left.

8. A. C. L. Case No. 470. Seventh cervical vertebra negative.

9. J. S. Case 1212. Prominent transverse processes especially on right of seventh cervical vertebra.

10. D. S. Case No. 597. Very prominent transverse processes especially on left of seventh cervical vertebra.

11. C. M. Case No. 1952. Prominent transverse processes of seventh cervical vertebra.

12. D. Z. Case No. 1103. Very slight prominence of transverse processes seventh cervical vertebra. There is, however, considerable irregularity and roughening of distal surfaces.

13. M. H. Case No. 3441. No evidence of cervical ribs or prominent transverse processes.

14. C. R. Case No. 3127. Transverse processes, especially on right, of seventh cervical vertebra are slightly prominent.

15. E. A. Case No. 918. Negative for cervical ribs.

16. J. H. Case No. 1414. No cervical rib. Prominent first thoracic rib on right and very prominent seventh cervical transverse processes.

17. J. R. Case No. 3260. Negative. Rudimentary first thoracic rib on left.

LIST NO. 4.—THORACIC RIB ANOMALIES

All Male Patients

1. S. R. V. Case No. 469. On right, fusion of first to second rib. First rib on right is much narrower than the first rib on left. Thorax slightly asymmetrical. (Fig. 16.)

2. M. T. Case No. 793. On right, a bifurcation of third rib from midclavicular line to costal end; bifurcation approximately 5 centimeters in length. Ribs well formed. Thorax symmetrical.

3. B. Case No. 720. On right, fusion of first to second rib. Fusion complete from articulation to within 2 centimeters of costal end. Combined width is 4 centimeters as compared to 1.5 centimeters of the first rib on left.

4. F. H. Case No. 434. On left, first rib undeveloped, is 5 centimeters in length, apparently not fused to second rib. The first rib on right is 10 centimeters in length. Thorax symmetrical.

5. C. Case No. 252. On left there is fusion of the first with the second rib at its middle portion. The ribs run down parallel with the vertebral column.

6. Z. Case No. 149. On left, fifth rib, midclavicular line, is bifurcated.

7. T. Case No. 995. On right, fourth rib, midclavicular line, is bifurcated.

8. F. Case No. 663. On right, fourth rib, midclavicular line, is bifurcated.

9. M. Case No. 676. On right, fourth and sixth ribs are bifurcated. On left, midclavicular line, fifth rib is bifurcated.

10. S. Case No. 843. On left, fourth rib, midclavicular line, is bifurcated.

11. W. Case No. ———. On right, fourth rib, near anterior axillary line is bifurcated.

12. M. Case No. 435. On right, first rib is considerably decreased in size.

13. J. R. Case No. 3260. On left, a rudimentary first thoracic rib.

Since completing this paper two other cases with especially typical history and with marked unilateral nerve and vascular symptoms of cervical rib pressure have proven to be negative.

The last group of cases, List No. 4, with 13 cases, is included only because of its interest, the anomalous condition of first thoracic ribs has of course an especial interest, and secondly because they were rib anomalies that had no co-existing anomalous condition in the cervical region. None of these cases gave symptoms. In all 21 cases of cervical ribs and 13 of rib anomalies, no co-existing anomalous conditions were found. Another interesting anomalous condition was found in the case of a patient who had a bifurcated spinous process of the third cervical vertebra. Finally, it may be pointed out that variations in the eleventh and twelfth dorsal and in the transverse processes of the lumbar vertebræ have been observed a great many times and that several cases with six lumbar vertebræ have also been seen. With the exception of symptoms arising from pressure on the transverse processes of the fifth lumbar vertebra, no cases presented any symptoms referable to these anomalies.

Specimen rib. The rib is in the osteological collection of the Yale School of Medicine; its history, however, is unknown. The length of the rib is 9 centimeters but the ventral 4.5 centimeters are fused with the superior surface of the first rib, the fusion beginning 1 centimeter anterior to the tuberosities, thus making the first rib bicipital. Although fusion is complete, except for the posterior centimeter, nevertheless the body

of the cervical rib is demarcated laterally by a slight groove running almost its entire length and medially by a shallow groove 1 centimeter in length at the ventral end, so that the outline of the body of the cervical rib is indicated by an elevated area and the grooves just mentioned. The body, which posteriorly is 7 millimeters vertically in thickness and 13 in breadth, tapers ventrally and reaches the posterior edge of the groove for the subclavian artery. On the superior surface an oblique groove 2 centimeters in length runs forward from the tuberosity to the medial edge. The significance of this groove is not evident. The ventral end of the rib undoubtedly gave attachment to part of the scalenus medius muscle.

The head of the rib begins 7 millimeters lateral to that of the first rib and is rounded, resembling the head of the first rib. It shows a single articular facet which looks upward, backward, and medially, while that of the first rib faces somewhat downward. The head of the first rib, judging by the appearance of the facet, articulated with the centra of both the seventh cervical and first thoracic vertebræ.

The neck is 3 centimeters in length, somewhat rounded near the head but enlarging, and acquires a breadth of 15 millimeters near the tuberosity. It lies 7 millimeters above and parallel to the neck of the first rib, which it resembles in shape, size, and appearance. The upper and lower surfaces are rough and porous.

The tuberosity of the cervical rib is larger, more knob-like and prominent than that of the first rib and projects more dorsolaterally. The articular facet, larger than that of the first rib, is slightly convex and triangular in outline, with the apex directed medially and looks backward and medially as does that of the first rib.

It is altogether probable that a cervical rib of this type would not produce either motor, sensory, or vasomotor disturbances or interfere particularly with the apical expansion of the lung.

These cases were obtained from the New Haven Dispensary, New Haven Hospital, and the U. S. Army General Hospital No. 16.

In conclusion, I wish to thank Miss M. A. J. Barrett for her kindness and generous assistance in looking up the cases and Mr. Earl Furbush for the trouble and interest he has taken with the roentgenographs and photographs. I am indebted to Dr. H. B. Ferris of the Department of Anatomy for the excellent description of a right cervical rib, illustration of which is given here.

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BRACHIAL BIRTH PALSY AND INJURIES OF SIMILAR TYPE IN ADULTS [1]

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THIS presentation will be limited to a discussion of the lesions of the "obstetric palsy" type and the precisely similar lesions which occur in adults under the name of "Erb's palsy." The subject is again brought forward because of the widely divergent opinions which prevail in different groups of the profession, as to the etiology, pathology, and especially as to the best form of treatment in these cases. First the birth palsy group will be discussed.

Nearly all neurologists and pediatricians, and they are the ones who first see these cases in infants, believe and state that spontaneous *cure* will occur in practically all cases after a sufficient interval of time provided proper care is given.

Personal experience, extending over some sixteen years, has thoroughly convinced me that the majority do not obtain a perfect recovery no matter how much time elapses and no matter what systematic treatment is given. Even surgical repair of the damaged nerves seldom gives a perfect physiological recovery.

The majority of these cases occur in the children of the poor. They are bound to become cripples in greater or less degree and to remain a burden to the family and a tax on the community. It is, therefore, important both for the child and the community that there should be some consensus of opinion among the various branches of the profession as to what constitutes the best system of treatment for these children.

The question at issue, then, is whether repair of the nerves gives average results so much superior to those following any other form of treatment that surgical interference should be given the preference. Before arguing this question it is necessary to present certain material as a basis for the deductions to follow.

To digress for a moment, the discussion would not be complete without mentioning the radically different views of T. T. Thomas, of Philadelphia, who maintains that obstetric palsy is not a nerve lesion primarily but rather an injury of the shoulder-joint capsule associated with subluxation of the shoulder and often with a secondary infiltration of the plexus nerves. Following the presentation of his paper, the careful examination of a number of very young infants with obstetric palsy elicited the following facts: No infant under three weeks of age showed any degree of the posterior subluxation supposed to be the cause of the palsy. The subluxation appeared at any time from three weeks to several months after birth and gradually increased in degree. In one case operated upon the subluxation gradually disappeared as the nerves and muscles resumed function.

Moreover in a number of cases operated upon the upper roots of the plexus were torn across and the ends displaced; in others, one or more roots were avulsed from the cord, and in none of these cases was there any continuity between the cicatricial mass about the nerves and the capsule of the shoulder-joint. These few briefly-stated facts would seem to indicate that the essential lesion was not damage of the shoulder capsule, but rather a true nerve lesion It is imperative to be right on this matter in order to have a correct basis for treatment.

Assuming then that the lesion is intrinsically of the nerves, the following brief statements are pertinent: The sole cause of the nerve damage is overstretching caused by separation of the head and shoulder on the paralyzed side. From the anatomical disposition of the nerves, the upper roots get the strain first; after they begin to yield the lower roots get it. For this reason the palsy is most marked in the upper root zones. The roots may be slightly overstretched causing temporary palsy followed by rapid recovery. The roots may be entirely torn across and the ends displaced. Between these two extremes there

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may be any number of variations so that no two cases are likely to be of exactly the same severity. The lesion may involve part of one root, or all five roots or any variation between these two extremes. The lesion may be at the origin of root from cord "avulsion of the root" or it may be at the lower portion of the plexus or at any site between these extremes. In addition to the intrinsic nerve damage, there is present, in all but the mildest cases, tearing of the deep cervical fascia just anterior to the plexus, and also of the scaleni muscles.

There is present, then, torn fascia, torn muscle, torn nerve sheath and torn nerve, all infiltrated with blood from the torn vessels. As time passes a hard cicatrix binds all these structures together and forms an impassable barrier to regenerating nerve and to nerve impulses.

In addition to these immediate pathological consequences there are certain secondary pathological sequelæ if nerve repair does not occur. In the majority of cases the muscles are paralyzed in groups, resulting in characteristic attitudes of the paralyzed extremity as will be seen in the slides.

As time goes on the joint ends of the bones grow misshapen to accommodate these attitudes, the ligaments and muscles contract and finally we have organic deformity replacing functional attitude.

Herein lies the strongest argument for early nerve repair, since these organic deformities have appeared in many cases despite the most persistent attempts to prevent them.

Symptoms. Just after birth in the majority of cases the extremity lies fully extended with marked inward rotation of the humerus and pronation of the forearm, so that the palm of the hand faces backward and outward. In severe cases there will be no movement of any portion of the extremity. In less severe cases there will be motion in the digits, and possibly in the hand and wrist. In mild cases there will be motion in the forearm, elbow, and possibly in some shoulder muscles, depending upon the number of roots involved and the degree of injury. The paralyzed muscles are in groups associated with the root distributions.

It must be remembered that the upper roots suffer first and most and the lower ones later and according to the degree of force involved, so that the upper one or two roots may be more or less completely and permanently damaged while the lower ones are merely overstretched. This corresponds with the clinical history of the majority of cases, in which, at first, there is complete loss of power, followed after a varying period by return of voluntary movement in the digits, then hand, wrist, etc., up to the level where the roots which have been permanently damaged prevent further recovery. This stage of recovery in the lower roots may extend over a period of two years, but meanwhile the complete loss of function in the upper roots leads to the development of the secondary pathological changes and organic deformities previously enumerated.

Proper appreciation of these facts is of great value in determining the method of treatment.

The usual underdevelopment of the shoulder girdle on the damaged side interferes with the child's balance and causes frequent falls.

Sensory disturbances are not marked as a rule. When the fifth and sixth cervical roots only are involved no sensory disturbances can be determined. In rupture of the entire plexus there is complete anæsthesia. Between these two extremes there are all grades of disturbance according to the lesion. The surprising absence of sensory disturbance is due to the interlacing of the sensory fibers of neighboring roots.

In practically every case the cicatricial mass previously mentioned can be felt over the nerve roots on the damaged side.

In adults, the Erb's type of paralysis is precisely the same as the birth palsy in etiology, pathology, and symptomatology with the exception that the developmental defects naturally do not occur in full-grown adults.

From the facts presented, one may proceed to the discussion of treatment upon which there is the widest divergence of opinion.

To those who say that operation is contraindicated because spontaneous recovery occurs in practically all cases, it is pertinent to

state that all orthopedic dispensaries have many of these children from 5 years of age upward who are seriously crippled. If the charge is made that they were not properly cared for it is only necessary to state that a number of children from 2 to 10 years of age have been brought for surgical repair after persistent and consistent treatment had failed to develop a satisfactory extremity. Surgical repair has been followed in most of these cases by comparatively prompt and very marked improvement.

Obviously there is a field for surgical nerve repair. In what cases and when is operative interference to be undertaken?

Perhaps a series of statements based upon personal experience will be the shortest way to a logical answer.

1. The great majority of cases do not get well spontaneously either with or without the best expectant treatment available.

2. The small minority of cases that do recover spontaneously are almost completely well at the end of three months.

3. Many of the cases operated upon have shown one or more roots torn across with the ends displaced; nerve roots avulsed from the cord; or damaged areas filled with very dense scar tissue. Such lesions do not recover spontaneously.

4. Clinically it is impossible to determine the precise nature of the lesion at an early period and its extent can be properly appreciated only after the lapse of one or two years. Meanwhile mal-development is occurring.

5. The earlier the nerve repair occurs whether spontaneously or with surgical aid, the more promptly will nutrition and function recover their balance and prevent the occurrence of deformity.

The question as to operation must also be influenced by the degree of intrinsic risk in the procedure.

Operation consists in an incision at the base of the neck through skin, platysma, and the underlying fat pad. When these are retracted the damaged nerves and adherent cicatrix are exposed. The various nerves are then dissected out and such repair work done as is found necessary. Ordinarily the amount of blood lost is very slight. In the very extensive cases, especially those involving the lower roots, there is occasionally a serious loss of blood from damage to one of the large veins. Aside from rare accidents of this kind there is no risk beyond that of the anæsthetic.

From the foregoing facts the only logical deduction is that surgical repair of the nerves is indicated in the great majority of cases and at an early period.

In cases which are obviously mild at the start one may expect a spontaneous recovery which will be nearly complete by the end of three months. Therefore operation is not indicated.

In the more serious group in which almost the entire musculature of the extremity is primarily paralyzed and the lower roots show no tendency to spontaneous recovery in the first few days, it is practically certain that a permanent lesion has occurred, at least in the upper one or two roots, and early operation is indicated.

Naturally in the still severer types of injury, early operation is indicated without question.

In the border-line cases, operation is more debatable and one must choose between early exploration and delay for three months to see what degree of spontaneous recovery will ensue.

If a case is explored and no nerve lesion requiring repair is found, the operation consists merely in an incision through the skin, platysma, and fat, examination of the plexus and closure of the wound. It is all finished in a few minutes. If a lesion requiring repair is found, valuable time is saved to the patient.

"Early operation" may be defined as one occurring in the first few weeks of life after the infant has become adjusted to its new world. This period therefore varies with the individual child, and with the judgment of the particular surgeon.

The disadvantages of operation in very early infancy lie in the very small field and small nerves which make the technical part of the suture more difficult. On the other hand the dissection is easier because the cicatricial tissue has not become so dense.

All things considered, experience may eventually indicate that the best results will follow operation at about three months of age.

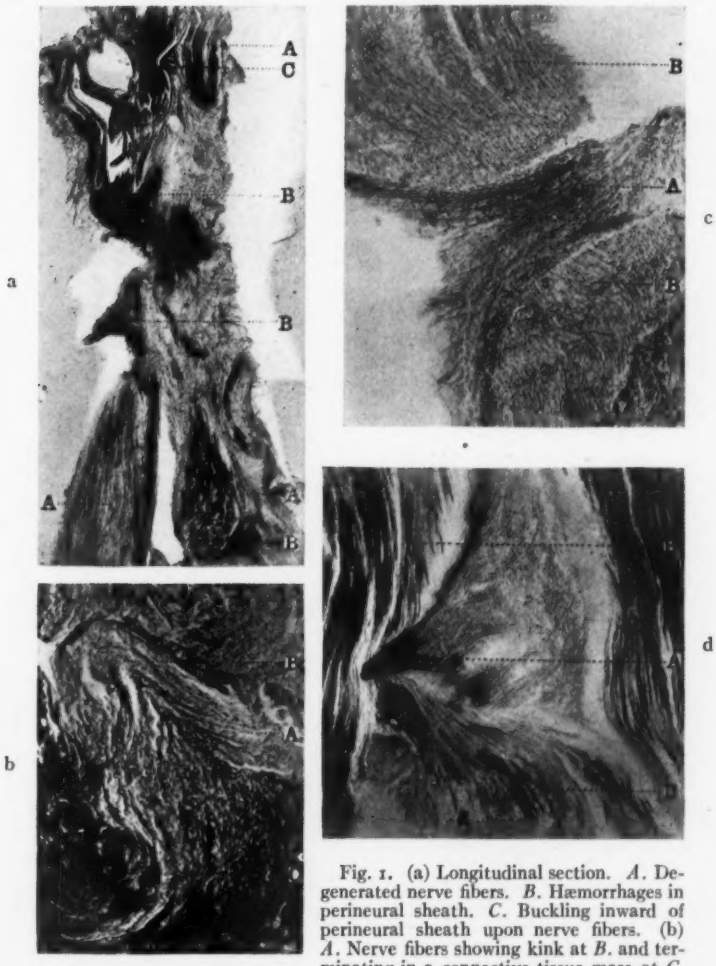


Fig. 1. (a) Longitudinal section. *A*. Degenerated nerve fibers. *B*. Hæmorrhages in perineural sheath. *C*. Buckling inward of perineural sheath upon nerve fibers. (b) *A*. Nerve fibers showing kink at *B*. and terminating in a connective tissue mass at *C*. which contains blood clot. (c) *A*. Band of connective tissue constricting nerve bundle *B*. (d) *A*. Buckling of perineural sheath compressing nerve fibers. *B*. Broken up remnants of myelin sheaths.

In all cases, whether operation is to be considered or not, the extremity should receive systematic attention. It is of primary importance to retain the extremity in a position which relaxes the paralyzed groups of muscles. Abduction and external rotation of the upper arm, flexion of the elbow, supination of the forearm and hand, and extension of the wrist and fingers are indicated. This position may be retained by use of a brace such as is used by orthopedists in deltoid paralysis, and depicted later. Very young infants are intolerant of the fixation and their skin is sensitive. A good compromise consists in passing a loop of gauze about the wrist on the damaged side, pulling up the extremity until the hand is near the occiput and then fastening the ends of the gauze to the shoulder on the opposite side or to the clothing about it.

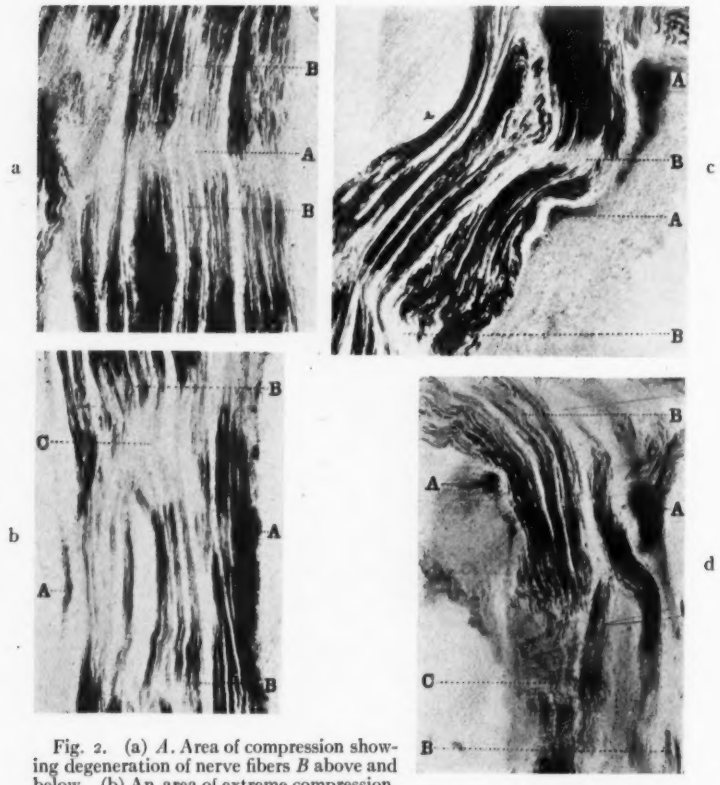


Fig. 2. (a) *A*. Area of compression showing degeneration of nerve fibers *B* above and below. (b) An area of extreme compression. *A*. Pigment from old hæmorrhage into perineural sheath. *B*. Broken up myelin sheath. *C*. Torn and compressed nerve fibers. (c) Buckling inward of perineural sheath with blood pigment deposits at *A*. Torn nerve fibers at *B*. (d) *A*. Pigment from old hæmorrhage into sheath. *B*. Myelin fragments. *C*. Torn and degenerated fibers.

NOTE: With the exception of (a) in Fig. 1 these specimens were all taken from cases that were several years old.

For the first three weeks no manipulation of the extremity is desirable, because it adds to the irritation already present in the damaged nerves and likewise to the pain.

After this period of irritation has passed, systematic physical therapeutics are essential both before operation and afterward, until such time as regeneration and return of function are nearly complete, a period of several years' duration.

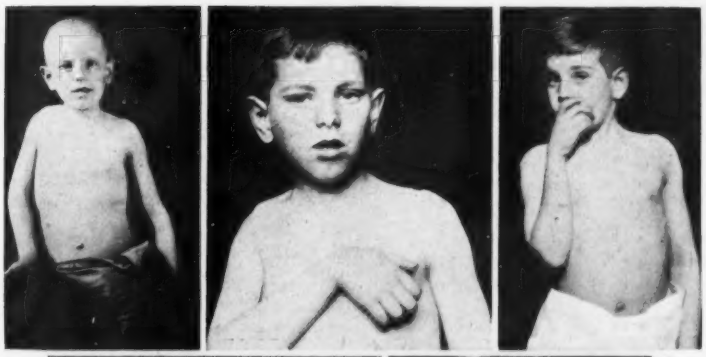
In my cases, operated upon, the extremity is maintained in the desired position by a brace, for three months, after which physical therapeutics are systematically employed.

For the relief of the acquired deformities in the older children two procedures have been developed by orthopedists. The dislocation at the shoulder is the chief factor preventing good use of what is left of the extremity.

Dr. Whitman overstretches, under general anæsthesia, the shortened muscles and ligaments about the joint, and, when they are loosened up, reduces the subluxation. A plaster cast is then applied holding the extremity in an overstretched position for several weeks.

This is a very serviceable procedure. It requires considerable strength, skill, and

Fig. 3. Fig. 4. Fig. 7.



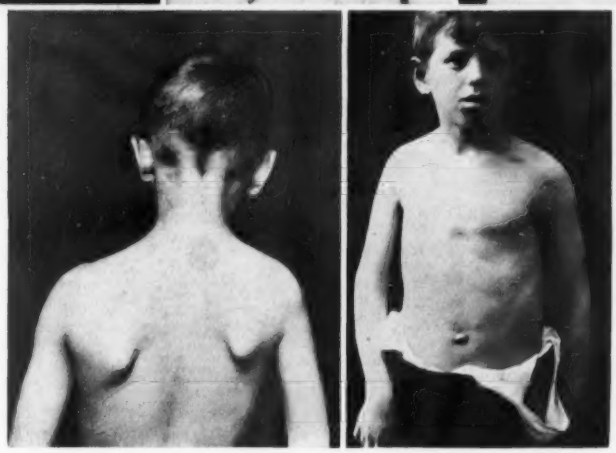


Fig. 5. Fig. 6.

Figs. 3 to 7 inclusive, are pictures of Case 3 in the operative series of birth palsy cases. This boy was 8 years old. He had a right birth palsy and had had intermittent treatment up to the time of operation.

Fig. 3 shows customary attitude, characteristic deformity of birth palsy type of serious degree. Useful function was extremely limited. The flexors of the fingers were fairly strong but the extreme flexion of the wrist neutralized the value of the hand.

Fig. 4 shows the limit of elevation of hand toward face before operation; also atrophy of deltoid.

Fig. 5 shows narrowness of the right shoulder girdle, under size of right scapula and marked posterior luxation at the shoulder.

NOTE.—Operation showed complete tearing apart of the fifth and sixth cervical nerves with dislocation of their ends from each other. The seventh cervical nerve was compressed and moderately damaged. The nerve ends were dissected free, sectioned transversely to remove scar tissue, and end-to-end suture done.

Fig. 6 shows markedly improved position and size of the right upper extremity 9 months after surgical nerve repair. (Compare with Fig. 3.)

Fig. 7 taken 31 months after surgical nerve repair shows flexion of the elbow, supination of the forearm, which was previously impossible, with approximation of the fingers to the face. (Compare with Fig. 4.)

judgment to overcome the contracture without fracturing the humerus, which in these cases is subnormal in size and strength.

There are two other drawbacks to this procedure. In many of these children the coracoid process becomes elongated and bent downward so as to furnish mechanical obstruction to complete reduction of the humerus. The coracoid process cannot be broken or displaced by manipulation. There is marked tendency to recurrence of the deformity the more so if the coracoid process

Fig. 8. Fig. 9. Fig. 10. Fig. 11.

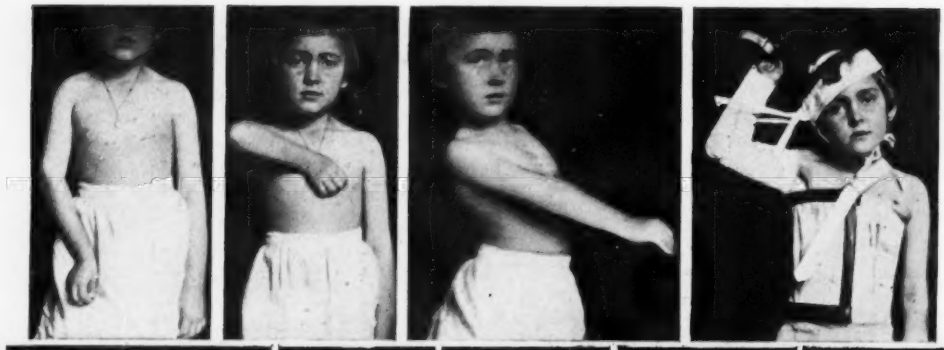
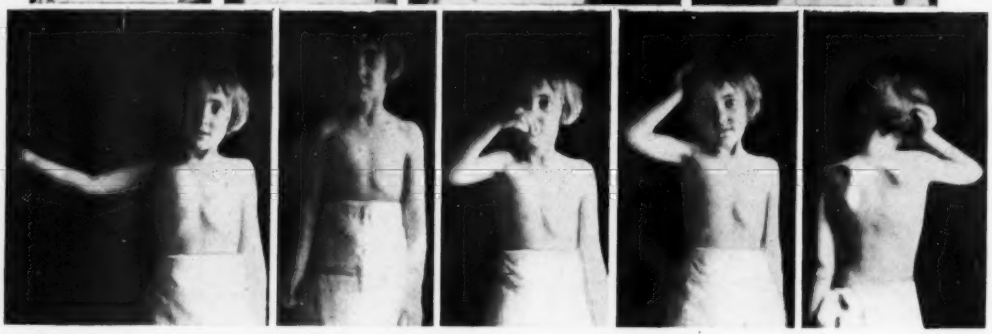


Fig. 12. Fig. 13. Fig. 14. Fig. 15. Fig. 16.



Figs. 8 to 16 inclusive are pictures of Case 62 in the operative series of birth palsy cases. The child was five and a half years old and she had received persistent massage, passive motion, and muscle training from the time of birth to the time of operation.

Fig. 8 shows the characteristic attitude of the right upper extremity before operation. In this case there was marked interference with the value of the hand, the muscles of the fingers not being very strong.

Fig. 9 represents the limit of elevation of the hand to the face. It illustrates the characteristic deformity in these cases where inward rotation of the upper arm prevents proper elevation of the hand.

Fig. 10 shows the limit of forward elevation of the right upper extremity.

NOTE.—The Sever operation was done first. The fifth and sixth cervical roots were nearly torn apart with cicatricial connection between the torn ends. The seventh cervical root was torn half way across. The eighth cervical and first dorsal roots were not macroscopically damaged. All of the roots were compressed by thickened cervical fascia which was dissected away. The damaged nerves were resected and end-to-end suture done.

Fig. 11 shows the brace used during the 3 months following operation. This relaxes all of the paralyzed muscles and approximates the head and shoulder on the paralyzed side preventing tension on the nerve sutures. This brace is worn without intermission during the first 3 months after operation. In this case Sever's procedure was added to surgical repair of the damaged nerves because of the marked contraction of the subscapularis and pectoralis major muscles.

Figs. 12 to 16 inclusive were taken 6 months and a few days after operation.

Fig. 12 shows free abduction at the shoulder, external rotation of the arm, well marked supination of the forearm.

Fig. 13 shows natural carrying attitude of the right upper extremity. (Compare with Fig. 8.)

Fig. 14 shows the freedom with which the hand can be approximated to the face, elevation of the arm, flexion at the elbow, supination of the forearm.

Fig. 15 shows all of the previous types of motion, bringing palm of hand to top of the head.

Fig. 16 shows the rear view of the same attitude. This child before operation had never been able to attain the positions shown in Figures 14, 15 and 16.

hooks down to a marked degree and interferes with free and complete reduction of the shoulder. Dr. Sever attacks the same problem by section of the pectoralis major and subscapularis tendons by open operation. At the same time, if the coracoid is in the way, its tip can be resected subperiosteally and its obstructing portion removed. Reduc-

Fig. 17. Fig. 19.

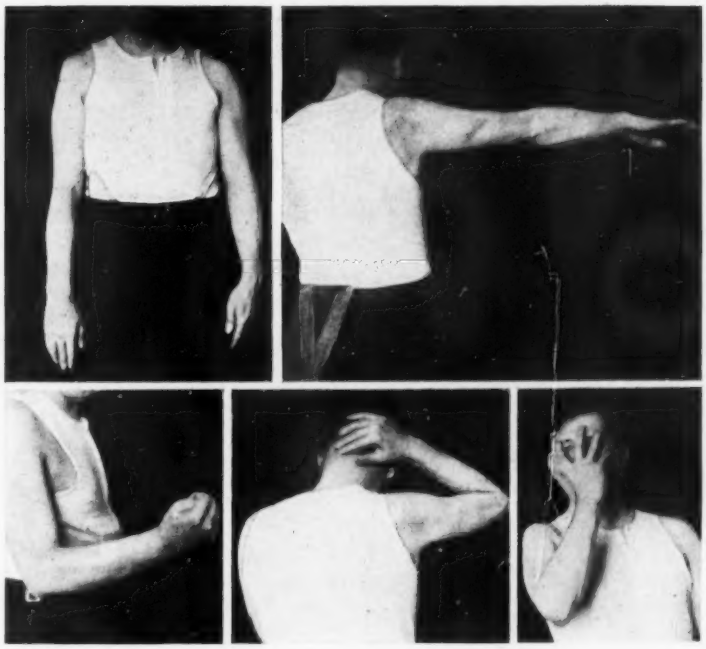


Fig. 18. Fig. 20. Fig. 21.

Figs. 17 to 21 inclusive are pictures of Case 9 in the operative series of Erb's palsy in adults. This man before operation had no power of flexion at the elbow and no supination of the forearm, but had fair mobility and slight strength in the digits and the wrist. He could elevate the extremity as a whole fairly well through the scapular muscles. There was little useful function in the extremity. These pictures were taken 9 months from the date of surgical nerve repair.

NOTE.—There was fracture of the right clavicle at its middle with marked overriding and excessive callus. The fifth and sixth cervical roots were torn and involved in scar tissue. The seventh cervical root was almost torn off and the remnant involved and distorted in the scar. The eighth cervical and first dorsal were simply compressed by scar tissue. The fifth, sixth, and seventh roots were resected and end-to-end suture done. The eighth cervical and first dorsal roots were merely released from compression.

Fig. 17 shows the natural attitude of the right upper extremity. Flattening of the deltoid is still obvious.

Fig. 18 shows strong flexion at the elbow and the making of a firm fist. There is also well marked supination.

Fig. 19 shows abduction at the shoulder without the scapula following the humerus too closely. There is free and normal motion at the shoulder.

Fig. 20 shows hand upon the back of the head which involves abduction at the shoulder, external rotation of the arm, flexion of the elbow and supination of the forearm, most of which had been previously absent.

Fig. 21 shows the same type of motion as in Fig. 20 resulting in carrying the palm of the hand to the face. All of these positions had been impossible preceding operation. To illustrate the degree of strength which had returned to the extremity he lifted a magneto weighing nearly ten pounds from the floor to a table about 30 inches high.

tion is then easy and there is no tendency to recurrence.

This operation leaves a fairly evident scar and the patient cannot afterward put the hand backward and upward to the scapula. Nevertheless other motions are so much more free as to render the net results a very great improvement. It is now my custom to combine this operation, in suitable cases, with nerve repair, in one sitting.

Final results in a considerable number of cases must be the criterion by which one method of treatment is judged to be superior to others.

My series of cases of birth palsy operated upon now totals 70. Of cases seen but not

operated upon because of refusal of parents or physician there were more than 130. Of these 200 only 10 were two months or less of age when first seen. Of these, only two made spontaneous recoveries; one complete by the end of three months and the other so nearly complete by the end of three months that operation was not to be considered. This 1 per cent of spontaneous recoveries is perhaps so small because the majority of cases were several months or more old and the time for spontaneous recovery had passed.

Of the 70 operative cases three died. The very first case died 20 hours after operation with a temperature of 107° F. The pathologist believed the case to be one of status lymphaticus.

The fourth case of the series developed a violent gastro-enteritis the day after operation and died a week later.

The sixty-seventh of the series died on the table from sudden severe hæmorrhage due to injury of one of the large veins at the base of the neck which was adherent to the dense scar tissue involving the whole plexus region.

FUNCTIONAL RESULTS

Concerning the functional results, there has been no perfect anatomical and physiological recovery. With a few exceptions, in which the damage has been found to be irremediable, these children have made marked improvement and many of them have attained almost perfect function in the extremity.

In a number of cases to be illustrated by slides physical therapeutics were relied upon by the parents and physician for a period of two to four years and when improvement had ceased for a long interval operation was done and the result was a marked improvement. This improvement therefore is solely attributable to the operation.

Of the Erb's type of paralysis in adults there were 14 cases operated upon. In 7 of these one or more roots had been avulsed from the cord, thus showing a much higher percentage of very severe injuries than occurs in birth palsies. The results were unsatisfactory.

Of the remaining 7, 3 were lost to view. Of the remaining 4, 1 case made a perfect recovery, 1 made an almost perfect recovery, 1 made a good recovery, and 1 made a very little improvement probably because he removed his dressings, stretched his head and neck and probably pulled apart the sutured nerves.

There was no mortality.

RECURRENT VESICAL CALCULI ASSOCIATED WITH CALCULUS IN DIVERTICULUM AND CONTRACTURE OF VESICAL ORIFICE

By EDWIN G. DAVIS, M.D., F.A.C.S., Omaha
From the Department of Urology, University of Nebraska College of Medicine

OWING to recent advances in the methods of urological diagnosis, the frequency of vesical diverticula has come to be generally recognized. In marked contrast with the literature of 20 years ago, when the *Surgeon General's Index Catalogue* recorded less than ten publications concerning vesical diverticula, and about the same number of cases of sacculated bladder (most of these based on autopsy findings), is the voluminous literature of the present date upon this subject, containing contributions from many prominent surgeons and urologists. The etiology of diverticula has been widely discussed, and there have been plausible theories advanced to prove either their congenital or acquired origin. In lack of conclusive evidence, the most generally accepted view is that the primary cause is an embryologic defect, and that urinary obstruction may later play a part in development. It is also generally recognized that diverticula are found usually associated with obstruction of the lower urinary tract.

In view of this extensive literature, a case of simple bladder diverticulum is not of particular interest; and even cases of calculi contained in diverticula are not unusual. The case reported herewith is of unusual interest, however, in that the recurrent vesical calculi were associated with a residual urine due to a contracture of the vesical orifice, and in that it was definitely shown that the recurrent vesical calculi formed in turn upon a spicule projecting into the bladder from a calculus contained in a diverticulum.

The patient, a male, age 25, referred by Dr. LeRoy Crummer, complaining of dysuria, small stream, frequency, stoppage of urine, and general malaise and loss of weight, gave a history of four previous suprapubic cystostomies during the preceding 12 years. In two instances vesical calculi had been removed, and the other two were apparently merely

Fig. 1. Roentgenogram showing oval-shaped calculus with projecting nipple, lying far to the right of the midline, and therefore presumably extravesical.

Fig. 2. Cystogram demonstrating that calculus shown in Figure 1 is extravesical and is contained in a diverticulum, which is connected with the bladder by a narrow isthmus.

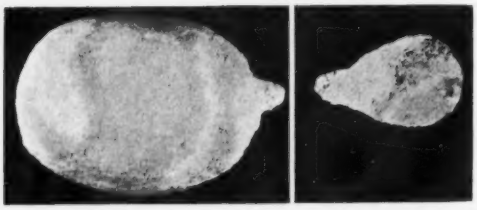


Fig. 3. Photograph of oval calculus with projecting nipple removed from the bladder by suprapubic cystotomy.

Fig. 4. Photograph showing shape and size of calculus removed from diverticulum. The projecting nipple shown in this calculus, and that on the calculus shown in Figure 3, were presumably at one time united, forming a dumb-bell shaped calculus contained partially in the bladder and partially in a diverticulum.

for drainage. After each operation the fistula was many weeks closing. There was a history also of marked difficulty in urination and small urinary stream since the patient's earliest recollection. The patient stated that as a boy his stream of urine was always smaller than that of other boys.

The striking feature in the history, upon which it was possible to base a snap diagnosis without examination, was the fact that after the first operation there was complete comfort for several months (except for small stream which he had had all his life) and that the old train of symptoms (pain, frequency, stoppage) *suddenly* recurred, almost instantaneously. At second operation the patient stated that a calculus was removed measuring 3 by 4 by 6 centimeters, oval in shape, with a projecting spicule on one end. This calculus had existed in the bladder for months without symptoms.

General physical examination was negative except that the patient was anæmic and showed signs of loss of weight. The external genitalia were normal. Suprapubic region showed extensive scar formation.

Rectal examination showed a small fibrous prostate and a moderate induration in the region of both seminal vesicles. The vesical diverticulum was not palpable.

The urine was foul-smelling and purulent, containing many pus cells and bacteria, no albumin. After intramuscular injection of 6 milligrams of phenolsulphonephthalein, 45 per cent was excreted during the first hour.

Cystoscopy showed the urethra to be normal. There was moderate obstruction to the cystoscope at the vesical orifice. Residual urine, 200 cubic centimeters. The bladder capacity was not limited. There was a high grade diffuse cystitis, the mucosa nowhere presenting a normal appearance. Lying on the floor of the bladder was a calculus, apparently about the size of a bantam's egg. On the right lateral bladder wall about 3 centimeters from the right ureteral orifice was the small orifice of a diverticulum, and behind the trigone were two more orifices, still smaller.

The roentgenogram of the kidney region was negative. That of the bladder region (Fig. 1) showed an oval-shaped shadow, measuring 2 by 3 centimeters, with a nipple-like projection at one end, lying well to the right of the mid-line and for this reason presumably extravesical. The calculus seen through the cystoscope cast no shadow.

Cystogram with the bladder filled with sodium iodide solution (Fig. 2), showed the above-described shadow to be entirely extravesical and contained in a diverticulum connected with the bladder, as demonstrated by a small isthmus connecting bladder shadow and calculus. Figures 1 and 2 show that the diverticulum is entirely filled by the calculus.

Pre-operative diagnosis. Of the existence of a diverticulum containing a calculus, and of an additional vesical calculus, there could be no question. Considering the patient's history of *instantaneous* recurrence of symptoms after a free interval of several months, and his description of the calculus removed being oval in shape with a projecting nipple, it was not unreasonable to assume that the two calculi had been attached, and the vesical calculus therefore suspended. To account for the residual urine, the diagnosis of contracture of the vesical orifice was arrived at by exclusion of other causes of obstruction.

Operation. Suprapubic cystostomy. Removal of vesical calculus, and excision of a diverticulum containing a second calculus. Punch operation for contracted vesical orifice.

On account of excessive scar tissue formation, it was with considerable difficulty that the peritoneum was dissected free and the bladder opened. The residual urine was very purulent and foul-smelling. An oval calculus, measuring 3 by 4 by 6 centimeters, with a projecting spicule at one end (see Fig. 3) was removed. There were two small diverticula behind the trigone, each about thimble-sized, and empty. No attempt at excision was made. The third diverticulum, about the same size, containing the above-described calculus (Figs. 1, 2, and 4), was exposed by an extravesical dissection of the right posterolateral aspect of the bladder, and excised *in toto*. The opening into the bladder was closed with catgut and the site of the diverticulum drained extravesically.

The most important feature of the operation was the dense fibrous contracture of the vesical orifice, making the insertion of the tip of the little finger impossible. This condition was relieved by the use of Young's punch instrument, the procedure being very simple because it was aided by a hand in the bladder. Closure was made with prevesical drainage and a tube in the bladder.

Postoperative history. The first few days of convalescence were critical on account of hæmorrhage from the perivesical dissection and on account of a temporary suppression of urine. The suprapubic scar tissue caused delayed closure of the fistula, so that a secondary operation under local anæsthesia was finally necessary. Seen 4 months

after operation the patient was symptom-free, had no residual urine, and was passing a large, normal stream for the first time in his life.

CASES IN LITERATURE

Reports of calculi contained in diverticula are not rare. Out of Judd's (1) series of 44 diverticula, there were 4 containing calculi, and there are many other such cases in the literature. There were, however, only 2 cases to be found in which there was a dumb-bell-shaped calculus, contained partly in a diverticulum and partly in the bladder. One of these, in which the dumb-bell calculus was removed intact, was included in Judd's series, and was reported in detail by Martin (2). Here there was no history of recurrent calculus-formation. In the other case (Young, 3), calculi continued to recur after several suprapubic cystotomies and litholapaxies, and after a perineal prostatectomy, until finally, by cystoscopy, the small orifice of a diverticulum was observed. Through this orifice there projected a small spicule of stone. At operation, a calculus was removed from the bladder and another from the diverticulum, each with a projecting fractured point, the two fitting together. There was no further recurrence of calculi. In this patient's previous record there was likewise a history of complete relief for several months after operation, and then *sudden* recurrence of symptoms (frequent and painful urination), presumably on the occasion when the connecting isthmus between the two calculi gave way, and the vesical calculus was allowed to drop to the floor of the bladder. This case is analogous to the one reported above, in that in each there was successive calculus-formation upon a spicule of stone projecting into the bladder, and acting as a foreign body. The two differ in that in Young's case there was no residual urine (after prostatectomy) and yet the calculus-formation continued.

The finding of a contracted vesical orifice associated with a diverticulum is in keeping with the report of Hinman (4), who, in a series of 21 bladders with diverticula, made the surprising observation that 13 showed a contracted vesical orifice, while four more were of the fibrous ring type of prostatic hypertrophy. The co-existence of these two conditions is therefore not unusual, and the frequent association would tend to indicate more than mere coincidence. As to which is the primary etiological factor, proof is wanting.

CONCLUSIONS

The above case is of interest because of its uniqueness, and because it illustrates the futility of removing a vesical calculus without looking for an underlying cause of calculus formation. Here there were two etiological factors, a residual urine and a foreign body, either of which was adequate cause for recurrence.

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A CONSIDERATION OF THE LATENT STAGE AND OF THE PERIOD OF REINFECTION IN MASTOIDITIS DUE TO STREPTOCOCCUS MUCOSUS CAPSULATUS[1]

By FRED WHITING, M.D., F.A.C.S., New York City

Of the many infecting organisms which we encounter as responsible agents in the production of inflammation of the mastoid, the streptococcus mucosus capsulatus is not only the most virulent in its destructive properties but the most insidious in its progress as well. In considering the peculiar manifestations which characterize the course of mastoid inflammations due to the pernicious activity of this agent, there are two significant features which distinguish it from the pathological processes instituted by other members of the streptococcus family.

The first of these peculiarities is characterized by a disposition of the acute inflammatory processes which usher in the attack of mastoiditis to abate and for all active symptoms temporarily to subside or disappear. This phase of the disease which we denominate "the latent stage," is encountered immediately after the early acute manifestations have reached their height and is likely to beguile both the patient and his medical adviser into a sense of fancied security from which they experience a rude awakening on the sudden reappearance of all the early acute symptoms.

These are revived in a greatly exaggerated form usually heralded by a chill and followed in orderly succession by unmistakable evidences of meningitis. The progress of the disease from this point forward is distressingly rapid and the termination almost inevitably fatal. The onset of these mucosus infections resembles that of any other otitis media, but as soon as the pain is relieved by spontaneous rupture or an incision of the membrana tympani, the case from that time on is characterized by an entire absence of symptoms; there may be complete disintegration of the mastoid structures and aside from the discharge, the patient will insist that he feels no discomfort. This condition continues throughout the entire latent stage, without pain, temperature, mastoid tenderness, or prostration, and if uninterrupted by operation meningitis finally supervenes, and the death of the patient occurs.

It is of the most vital importance that the presence of this organism be recognized as early as possible and that it may not escape detection, a careful cultivation should be made of the ear discharges of all patients where opportunity permits. The unscientific attitude of those practitioners who decry as a needless refinement of medical practice the disposition of otologists to insist upon knowing the nature of the infecting organism, and who entertain a manifest pride in the dictum that "pus is pus," is quite indefensible when we consider the high percentage of mortality which attends upon those cases of mucosus infection which are permitted to drift along with an unwarranted sense of security through the latent stage without operation, because the organism has not been recognized and the surgeon thereby placed on his guard.

The method of conducting the treatment of a case of mucosus otitis as soon as we are aware of the germ with which we have to deal differs in no respect from the treatment of other suspected mastoid inflammations save that it is very important that roentgenograms should be repeatedly made at brief intervals until all discharge has ceased and until the fundus has resumed its normal physiological appearance. In the X-ray plate we possess a diagnostic aid in determining the increment of conservative safety for the patient as well as the most favorable moment for operation, the importance of which cannot be overestimated and those of us who are fortunate enough to be able to command the services of that master of X-ray technique, Dr. George Dixon, will gladly testify to the unfailing accuracy with which his plates reveal the most craftily concealed structural changes of the mastoid bone. Given good roentgenograms

[1]Presented before the Clinical Congress of American College of Surgeons, New York City, October 21, 1919.

repeated with sufficient frequency and we can greatly reduce the dangers of the latent stage of mastoiditis due to the streptococcus mucosus capsulatus.

The second peculiarity which emphasizes the dangers of this type of mastoiditis should be denominated the "period of reinfection," which phenomenon may manifest itself at any time during the convalescence of the patient varying from a few days after operation, when granulations have only begun to cover the walls of the bone cavity, to a period when the healing is far advanced and even occurring in one case which I saw after the wound was completely healed.

The stage of reinfection, occurring as it usually does after the patient is measurably well along on the road to recovery and when his anxiety and that of his friends regarding an unfavorable termination has been allayed, is associated with particularly distressing consequences. The chill which almost uniformly announces the onset of the complication is followed immediately by severe prostration and as a rule meningitis develops rapidly and runs its course to a fatal termination in a few days uninfluenced by any measures, therapeutic or operative, which may be undertaken.

A brief summary of a case which came under my personal supervision will suffice to illustrate the insidious manner in which reinfection may develop, notwithstanding every indication that recovery is fully established.

The patient was a business man, of 35, who had always enjoyed good health and who 3 weeks before I saw him, had suffered an attack of grippe. In the course of this illness his ear became infected and he was seen by an otologist who opened the ear-drum and instituted the usual treatment for such a condition. The inflammation spread to the mastoid and he was advised to submit to operation. He declined this advice and consulted me a week later with all the classical signs of mastoiditis well developed. I advised operation to which he consented after deliberating a day or two. His roentgenogram showed extensive cavitation and the mastoid operation corroborated the X-ray plate in every detail. The dura was not exposed at operation.

He made a somewhat slow but quite uneventful convalescence, the wound healing kindly until there was only a shallow granulating pit very small in area over which a protective layer of gauze was held in place by a strip of adhesive plaster.

He had resumed his customary occupation and considered his recovery as fully established, when, while at work in his office, he suddenly experienced a chill associated with headache and prostration which compelled him to return home early one afternoon. Within a few hours he exhibited well-marked rigidity of the neck. Fluid drawn by lumbar puncture was distinctly turbid and upon subsequent examination was found to contain streptococcus mucosus. The progress of the disease was not arrested by subtemporal decompression and the patient died about 60 hours after the incidence of the chill.

While the experience just recited is distressing and most disappointing, it is, unfortunately, so common in mucosus infections as to occasion but little surprise, whereas a similar misfortune due to a different organism would be most unexpected and disconcerting.

It is evident, therefore, that the streptococcus mucosus is endowed with certain pathogenic properties not possessed by other representatives of the streptococcus family. The only demonstrable morphological difference between the mucosus and the numerous other types of streptococcus is the possession of a tough capsule to the protection of which it seems not improbable may be due at least to some extent its resistance to the germicidal action of the antiseptics which are commonly used for purposes of cleansing the mastoid wound during the process of healing.

If the writer may be permitted, he would like to offer a suggestion which he believes contains a hint of practical clinical value in the treatment of the granulating mastoid cavity during the course of healing. The suggestion is as follows: Do not, after completing the operation for mucosus mastoiditis, suture the flaps except at the upper and lower angles, thus leaving an open wound into which may be introduced gauze packing moistened with a weak solution of tincture of iodine about ½ per cent. The use of the moist iodine gauze dressing should be continued until the surface of the bone is invested with a complete layer of granulations. The importance of this expedient lies in the fact that strong solutions of iodine cause the deposit of an exudate within or beneath which those germs which have not been destroyed by coming into immediate contact with the iodine thrive and increase. The weak solution

does not cause the formation of any protective exudate and filters into all the open bone cells, within which isolated colonies of the organism are still lurking, thus being responsible for their destruction. As a further suggestion the most scrupulous care should be exercised in the introduction of the gauze packing during the healing of the wound in order that the newly formed granulations may not be lacerated, thereby exposing an absorptive surface to this virulent organism. As a feature of additional interest it is worthy of remark that diabetic patients of middle age, who are attacked by mastoiditis in a large percentage of cases exhibit streptococcus mucosus as the infecting organism and inasmuch as the laboratory has demonstrated that this germ grows with great luxuriance in a saccharin medium, it may be possible that an exhaustive study of mastoiditis in diabetics will disclose an interesting relationship which has not hitherto been appreciated.

In concluding this paper the writer would propound the following problem for the consideration of those colleagues who will discuss it. Are we justified in the belief that mucosus inflammations of the mastoid are attended with greater danger to the life of the patient than other streptococcus infections of that structure or is such an impression merely one of the many prevalent and misleading notions which a wider experience will demonstrate is not well founded? In the judgment of the writer mastoiditis due to streptococcus mucosus must be regarded as a very dangerous malady, from the serious consequences of which the patient can feel no security until the wound is permanently healed.

SYPHILIS AND PREGNANCY

A Preliminary Note

By WILLIAM J. YOUNG, M.D., Louisville, Kentucky
From the Department of Skin and Syphilis of the University of Louisville and Louisville City Hospital

SYPHILIS is receiving greater attention today than any other disease which afflicts mankind, not because of any appreciable increase in incidence of the malady but for the reason that the medical profession, the health authorities, and the general public have been made to realize the prevalence of the disease and its menace to those infected as well as those with whom the infected associate. There are so many possible avenues of infection that only by investigating and closing those most apparent is it possible even to make a start toward limiting the ravages of the disease or lowering its present incidence.

Of the male and female the latter is least likely to have any knowledge of being infected with syphilis. In acquired lues in the male there is usually sufficient clinical evidence (past or present), i.e., primary, secondary or gummatous lesions, to warrant the taking of a Wassermann. In the female, however, where the primary lesion is situated within or about the vagina, secondary manifestations being either absent or so insignificant as to be unnoticed by the patient, she may be totally ignorant of the infection until repeated miscarriages, stillborn children, intense headaches or gummatous lesions about the body attract the attention of her medical adviser and suggest the causative factor.

In fully 40 per cent of instances women present no syphilitic history, nor have they any knowledge of their condition, and it is oftentimes difficult to make them believe or understand the nature of their affliction. The fact that both primary and secondary lesions disappear, whether the patient receives treatment or not, is the principal cause of the prevailing misunderstanding.

The most pitiable condition brought about by ignorance concerning the disease is noted in the children of syphilitic women. This ignorance has been the cause of more sorrow and distress to seemingly well parents, and the means of populating more feeble-minded

institutions and insane asylums, than any other single factor of which I have knowledge.

When the possibilities of neisserian infection were shown to the medical profession and the public, measures were adopted by which the eyes of the newborn, be it a child of the highest or the lowest class, were subjected to instillations of argentum nitrate solution to prevent the development of ophthalmia neonatorum and probable ultimate blindness. The physician who neglects this precaution is held open to criticism irrespective of who the mother may be.

It is perhaps too radical to suggest that every pregnant woman have her blood examined for the spirochætæ of syphilis, but certainly when one has in mind the amount of social damage wrought by hereditary lues, it is not asking too much that obstetricians consider such a possibility and make careful inquiries when a pregnant woman first comes under observation.

During the last few years, at the Louisville Public Hospital, the routine measure has been adopted of making a blood Wassermann when each pregnant woman is admitted. The following table shows the results.

	Cases
Wassermann examinations made	267
Found negative	200
Found positive	67
1+	6
2+	11
3+	22
4+	28

Positive about 25 per cent; of these 18.7 per cent either 3+ or 4+.

I have no accurate record of the number of such syphilitic women who presented skin manifestations, but am safe in saying the percentage was very small. As some of the patients remain in the hospital for 5 weeks before accouchement, it is possible to administer antisyphilitic treatment (arsphenamin and mercury) with the prospects of insuring the birth of an apparently healthy child receptive of antiluetic treatment. Even where a positive Wassermann is found only a few days before delivery, it gives the mother and child an opportunity to begin treatment with the hope of an ultimate clinical cure.

When the Wassermann is found positive on discharge from the obstetric ward, the patient is informed of her condition and invited to return to the syphilitic clinic for further observation and treatment. The imperative need for "follow up" work among such patients is evident, as they are more or less from the lower strata of life and correspondingly ignorant. The mother with her household duties and new interests is wholly occupied and soon forgets the vital necessity of treatment. Unless the patients are followed by an intelligent social worker and made to realize the need for treatment, the chances are they will not be seen again until referred by one of the other clinics perhaps after irreparable damage has been done.

The greatest obstacle to the eradication of syphilis is the secretiveness of those infected. While it is impossible for us to prevent "the sins of parents being visited upon their children," by routine Wassermann examination it is possible to discover many cases of unsuspected lues and institute treatment for the parents as well as the children, the latter being innocent victims.

In the obstetric wards of the numerous charity hospitals throughout the country, doubtless thousands of unsuspected cases of lues could be found if a routine Wassermann examination were made when each patient was admitted, and the children of those infected could thus be properly treated and given a chance to become useful citizens. The mere fact that women of this class are unlikely to be aware of infection and totally unable to care for syphilitic offspring, is sufficient justification for recommending routine Wassermann examination.

CONCLUSIONS

1. Routine Wassermann examination should be made in obstetric wards of charity institutions when patients are admitted.

2. It should be just as much the duty of the obstetrician to ascertain evidence or history of lues in his patient as to conduct delivery.

3. Considering the source of patients in the charity institutions the percentage of syphilis associated with pregnancy (in Louisville) is not excessive.

DEPARTMENT OF TECHNIQUE

FRACTURES OF THE PATELLA, OS CALCIS, AND OLECRANON TREATED BY FISCHER'S APPARATUS

By D. FOLDES, M.D., Cleveland, Ohio

ERNEST Fischer, of Budapest, Hungary, described an apparatus in 1910 for the conservative treatment of fractures of the patella and presented patients treated with his method at the International Medical Congress in Budapest, in 1910. The apparatus is very simple and its application easy. His method solves two important problems: (1) mobilization of the knee-joint, and (2) bony union of the fragments.

There are all kinds of methods given in textbooks for the treatment of fractures of the patella, but mention is not made in American textbooks of the method presented below.

Before describing the apparatus I will give a brief résumé of Fischer's article published in the *Gyogyaszat*, Budapest, in 1910.

There are two methods of treatment: (1) the conservative and (2) the operative treatment. Nearly all the conservative methods except those of Bardenheuer and Tilanus consist in immobilization of the knee-joint. Bardenheuer keeps the fragments together with a constant, adjustable, and exactly measured force. The disadvantage of his method is that the patient has to stay in bed. Another conservative method using mobilization is the one described by Tilanus and applied by many prominent surgeons. Twenty-four hours after the injury the knee-joint is bent passively; 14 days later the patient walks with the help of crutches. With this method bony union is not obtained but in many cases there are good functional results.

Bony union is not always procured with operative procedures especially when mobilization is employed, and yet mobilization is really the proper method to be used in every injury of the knee-joint.

Firm bony union does not mean a perfect functional result if immobilization is employed after operation. Fibrous union procured with mobilization will in most cases give a good functional result.

According to Lucas Championniere any method whatever is better than immobilization. Immobilization causes atrophy of the quadriceps muscle, atrophy of the bone, shrinking of the ligaments, and ankylosis of the joint. The patients suffer more in the treatments of such secondary results than from the direct injury.

The advantage of the operative procedure should be the mobilization of the joint, and this advantage is lost when immobilization is employed following operation. If the operative measures employed do not keep the fragments together, how can it be expected that plaster-of-Paris bandages will prevent diastasis of the fragments? Such bandages impair the tonicity of the quadriceps muscle and have no influence on the position of the fragments.

Everyone fully realizes the fact that the functional result is more important than the anatomical result, that bony union depends on the elimination of the diastasis, that good functional results depend on the early mobilization of the joint and on the prevention of atrophy of the quadriceps.

Gulliver, in 1811, proved that the diastasis of the fragments due to the contraction and later to the retraction of the quadriceps muscle is the cause of the lack of callus formation. The ligamentum patellæ proprium is quite retracted also. MacEwen, Koenig, and Hoffa found another cause for the lack of callus formation in the interposition of the lacerated periosteum between the fragments.

The diastasis of the fragments depends upon the extent of the laceration of the fibrous tissue covering of the patella and of the reserve extension apparatus, i.e., the lateral ligaments. The hæmatoma also separates the fragments.

As a conservative treatment, Fischer's method solves the problem of approximation of the fragments and at the same time the mobilization of the joint, without causing diastasis when flexing the joint. Even postoperatively it is the best method to prevent separation of the fragments when mobilization is employed. It relieves the tension on the suture by overcoming the retraction of the quadriceps muscle.

Fischer's method is indicated for treatment of fracture of the patella—

1. When the fracture is not older than 2 weeks and the reserve extension apparatus is not torn. Laceration of the soft tissues can be diagnosed either by palpation or from the extent of the diastasis. If the diastasis is not more than 3.5 centimeters then we may conclude that at least the lateral parts of the extension apparatus are intact (lateral ligamentous attachment). And finally if the patient is able to raise his leg, it is understood that the extension apparatus is practically intact. But should the patient be unable to lift his leg this does not absolutely signify that the extension apparatus is torn, because the patient may not raise his leg because of the pain.

2. When no definite indication as to conservative or operative interference is found. In such cases Fischer advises extension for 12 days. If, during this time, one fails to get good coaptation, operation is indicated. The time spent with the extension is not lost because the fragments are closer to each other and the hæmatoma is smaller.

3. When the reserve extension apparatus is torn, when the diastasis is more than 3.5 centimeters, when the fracture is more than 2 weeks old. Then operative treatment with the application of Fischer's extension apparatus postoperatively is indicated.

The apparatus consists of a steel plate 30 centimeters long, 4 centimeters wide, and 1 millimeter thick as a base, furnished with three hooks at one end and 6 hooks at its other end. The force of this spring on bending is very great and can be adjusted accurately. One, two, three, or more plates may be added to the base and they are held together with a screw. The force of the traction can be increased either by bending the steel plates or by using more plates (Fig. 1). The apparatus can be used for fractures of the patella, olecranon, and os calcis, or in any case where traction is needed to overcome the separation of fragments.

The adhesive plaster stays are prepared as traction splints—both 60 centimeters long, one for the thigh, the other for the leg. Figures 2 and 3 show these adhesive traction splints.

The adhesive traction splints and the apparatus are applied as follows: The patient sits in bed with the leg extended, and while the assistant is holding the fragments in apposition the adhesive splint (Fig. 2) is placed on the anterior surface of the thigh in such a way that the point of convergence of the strips is upon the tendon of the quadriceps muscle, the divergent strips are placed

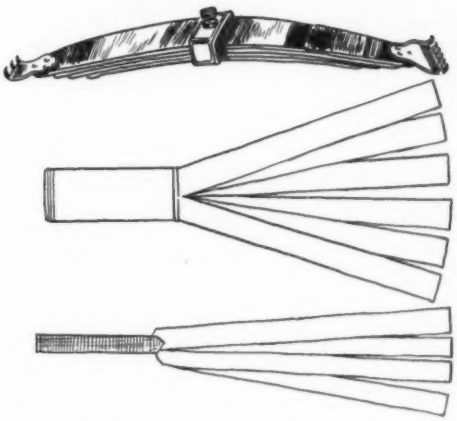

Fig. 1 (at top). Apparatus made of steel plates.
Fig. 2 (middle). Upper adhesive stay to be applied on the thigh.
Fig. 3 (below). Lower adhesive stay to be applied to the leg.

and held to the skin upon the quadriceps muscle. The longitudinal strips are reinforced with a few transverse strips and with a bandage. Adhesive splint 3 is placed on the leg in such a way that the point of convergence of the strips is upon the ligamentum patellæ proprium, and the divergent strips are placed at the inner and lateral sides of the leg. These strips are reinforced with adhesive running transversely three fourths of the circumference, so as to leave the edge of the tibia free, and a roller bandage is applied above these. On account of hæmorrhage it is advisable to apply a flannel bandage to the knee-joint for about 6 to 8 days.

After these adhesive splints are applied a hole is cut in the upper wider adhesive, and the lower adhesive splint is pulled through this opening. The ends of the adhesive strips are hooked on to the ends of the apparatus. As many steel plates are added and screwed on to the base as are needed. Figure 4 illustrates the apparatus in place. This apparatus can be substituted by a piece of hard wood 30 centimeters long, 2 centimeters wide, and 1 centimeter thick, straight or slightly bent having a pulley at each end (Fig. 5).

The adhesive splints are the same as described above except that the free end of the adhesive is cut shorter and a small piece of wood is inserted at its end and a cord tied to it. This cord is carried over the pulleys. Traction is made with rubber tubes attached to the cord with a ring (Fig. 5). The writer has modified this apparatus by replacing the rubber tubes with springs and

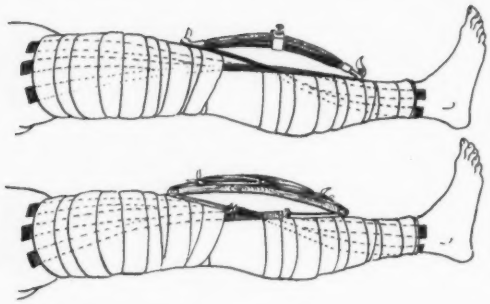

Fig. 4 (above). Steel apparatus in place.
Fig. 5. Wood and rubber tube apparatus of Fischer in place.

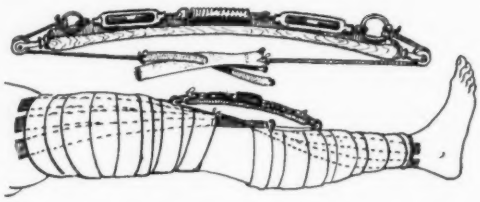

Fig. 6a (above). Same apparatus as in Figure 5, modified.
Fig. 6b. Same as Figure 5 modified. Rubber tube replaced by spring and turnbuckles.

turnbuckles (Fig. 6). This makes the application of the apparatus and the adjustments much easier. The traction is constant and can be accurately adjusted, by means of the turnbuckle. The springs and turnbuckles can be bought in any hardware store.

Important rules to follow are that: (1) the apparatus should be applied as soon as possible after the injury. (2) Full traction should be applied at once and not progressively and if 2 days later the X-ray still shows a diastasis then the traction has to be adjusted accordingly. (3) If the pressure on the skin of the patella caused by the adhesive is too much this should be corrected by suspending the apparatus above the bed, if the patient is lying in bed, or by placing cotton under the two ends of the apparatus to lift the adhesive from the skin if treated by ambulatory means. (4) After a few days when the danger of hæmorrhage is passed the patient may get out of bed and walk. The joint is bent passively many times daily, slowly and progressively.

The dressing has to be changed in 2 to 3 weeks. After 8 weeks the dressing is completely removed and active motion of the knee progressively begun.

As a conservative treatment this procedure is judiciously planned and gives good results, as the fragments are approximated with a constant and accurately adjustable force. With Fischer's apparatus the patient may dress, get out of bed and walk. Following its use the knee-joint will not be stiff, as it is moved passively from the first day on without the fear of producing a diastasis between the fragments. It prevents the eversion of the fragments by pressing on their anterior surfaces.

After operation the apparatus overcomes contraction and retraction of the quadriceps; relieves the tension of the suture material and prevents it from tearing; permits the patient to be out of bed, to dress and to walk; and permits examining the wound and changing the dressing if necessary.

The writer has applied the apparatus in a case in which the patella was fractured into several fragments, the lower one very small. The diastasis and swelling of the knee were considerable. As soon as the apparatus was applied the patient was able to lift his leg easily without pain or discomfort. The next day the patient was taken to the hospital where X-ray plates taken by Doctors Hill and Thomas showed the following:

On March 13, 1918, we examined the region of Mr. A. D's left knee on which an ambulatory splint had been applied. The plates showed a comminuted fracture of the patella with marked displacement of the fragments. The distal fragment was much smaller than the proximal one, and in addition to being displaced downward was rotated so that the fractured surface was anterior and the anterior surface was external. There was one small fragment within the gap between the two main fragments. After readjustment of the splint, plates were again taken which showed considerable improvement in the apposition of the fragments, but the rotation of the distal fragment was not perceptibly changed. After operation plates were taken which showed a very marked improvement in the position of the fragments, the small intervening fragment having been removed and the displacement and rotation of the distal fragment nearly overcome.

An operation was done 12 days after the injury because it was impossible to bring the fragments into good apposition. Local anæsthesia was used with a 0.5 per cent novocaine-suprarenin solution circuminjecting the operative territory subcutaneously and subfascially and injecting 20 cubic centimeters of the solution directly into the joint. Then the knee was bent and extended to distribute the solution throughout the joint and between the fragments. The anæsthesia was very good. The patella fragments were exposed by a semicircular incision. The fragments were brought together by an encircling chromic catgut suture, the torn capsule and ligaments sutured, the wound closed, and the apparatus applied. The patient left the hospital 4 days after operation and was treated at his home and later in my office. The treatment consisted in dressing the wound and passively bending the knee-joint daily. The apparatus was removed 6 weeks after operation at which date the patient was able to flex his knee to a

considerable degree and there was no difficulty in reaching a perfect result within a few weeks and without complaints.

The derangement of the knee-joint, the torn ligaments, and the interposition of soft tissues made the operation necessary, but the time which elapsed before the operation was not lost. The extent of damage found justifies the statement that the operation without mobilization would have caused a stiff joint, or at least considerable difficulty and pain would have accompanied the mobilization for several weeks. The patient was restored to work more quickly than would have been the case with immobilization.

Fractures of the olecranon receive very little attention in the textbooks, though this form of fracture is not so rare and, from the standpoint of future functional result, it is important that it should heal well.

Diffenbach advised tenotomy of the triceps tendon. Lister was the first to use antiseptics in performing primary suture of the fractured olecranon. Most of the textbooks advise operation; some of them advise conservative treatment such as the application of plaster-of-Paris bandages and splints. Hoffa applies adhesive strips on the posterior surface and splint or plaster-of-Paris bandage above this, the elbow being in extension; 6 weeks later when the dressing is taken off the elbow is bent passively. Bockenheimer punctures the hæmatoma, approximates the fragments by pressing on them with the finger, and applies an adhesive strip on the posterior surface of the elbow. On top of this, wooden splints are placed with the elbow in extension. In case of operation Bockenheimer advises, as a postoperative measure, traction with the patient in bed and the elbow bent at a right angle. The portable extension dressing of Bardenheuer is too complicated and less successful.

According to Lucas Championniere the immobilization methods are very bad. He claims that suturing is not necessary, that the contraction of the triceps is the cause of the diastasis which could not be overcome with any apparatus familiar to him. Championniere's results with massage and mobilization treatment are good.

Fischer's apparatus is very effective in the treatment of fractures of the olecranon inasmuch as a constant and accurately adjustable force pulls downward the olecranon dislocated upward, leaving the elbow free and permitting the passive flexion of the elbow without producing a diastasis between the fragments. The use of this apparatus as a postoperative measure is more sensible than the splints which immobilize the joint. The

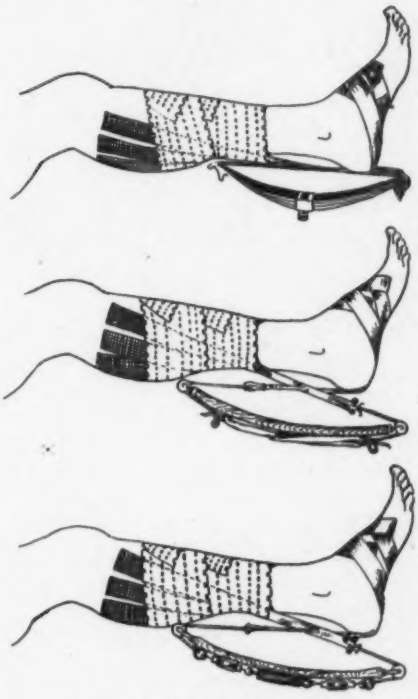

Fig. 7, a, b, c. Apparatus applied for fracture of os calcis.

apparatus relieves the tension of the suture and soon permits the passive flexion of the joint. The application of the dressing is similar to that for fractures of the patella.

I applied the same apparatus at the request of Dr. W. Stern, Mt. Sinai Hospital, Cleveland, in a case of fracture of the olecranon. The patient was a child, 18 months old. The wooden splint and the adhesive stays were smaller than those mentioned in the description being made to correspond to the size of the child's arm. The only difficulty in the application was caused by the swelling of the elbow. The result was very good. The X-ray plates taken by E. Freedman showed good apposition of the fragments.

Another fracture which is similar to fractures of the olecranon and which belongs to the typical fractures although it is more rare, is fracture of the os calcis produced by the sudden and powerful contraction of the gastrocnemius and soleus muscles. Several kinds of dressings are advised for the treatment of fractures of the os calcis, but these dressings act only on the distal fragment and have no influence on the proximal fragment which is

dislocated upward. The most popular treatment of such fractures is the conservative treatment which has the same effect as above. The foot placed in very strong plantar flexion, is held in a plaster-of-Paris bandage or in an apparatus made from a plaster-of-Paris model. The result of this treatment is atrophy of the muscles and a stiff ankle-joint.

The Bardenheuer dressing is the only one which approximates both fragments. The difficulty with this dressing, however, is that the adhesive strips producing the longitudinal extension are applied on the two sides and not on the posterior part of the leg; therefore they do not have sufficient pull on the muscles of the calf, also the patient must remain in bed for 6 weeks.

Fischer's apparatus for this kind of fracture is effective and simple. Figure 7 illustrates its application. This dressing approximates the fragments with great force, with a constant downward traction on the proximal fragment and upward traction on the distal fragment. The patient is not confined to bed and may walk with the help of a cane if the heel of the foot is raised. Early motion of the ankle-joint is permitted.

The same apparatus may be used in every fracture where traction is needed to overcome separation of fragments.

INDICATIONS FOR CHOLECYSTECTOMY AND A METHOD OF PERFORMING IT

By J. L. YATES, M.D., F.A.C.S., Milwaukee, Wisconsin

CHOLECYSTECTOMY is indicated when morbid changes in a gall-bladder or cystic duct have reached a stage from which recovery can be so imperfect that recurrent attacks of cholecystitis, subsequent development of gall-stones, untoward influences upon digestive functions, or malignant degeneration are probable or possible.

Cholecystostomy may be unavoidable as an urgency measure in the presence of any of the above conditions, in patients enfeebled by age or disease. This is particularly true in empyema of the gall-bladder with extensive adhesions, in the unusual types of chronic biliary obstruction when the hepatic epithelium, having lost its power to make bile, is secreting clear fluid—the so-called white bile—and in acute cholangitis. Under these conditions the release of pressure through free biliary drainage is an immediate necessity. Under these conditions also there is likely to be associated myocardial degeneration and such patients are particularly intolerant of prolonged drainage and of the absence of bile from the intestines.

After pressure is released by free drainage, patients of the types described enjoy a period of considerable improvement. The benefits will be more certain and more pronounced if a portion of the bile obtained in drainage bottles is diluted with water and returned by proctoclysis. After a week or two, particularly if free drainage persists, there is apt to begin a decline which may lead ultimately to death. The onset of this period is so gradual there is difficulty in recognizing it promptly. There is a decreased sense of well-being and an increase in the pulse rate. Possibly a safe index is the nature of the wound repair; the healing processes abruptly become retarded. Just at this time cholecystectomy may be life-saving and by the same token may be the strong argument for cholecystostomy with choledochotomy as against choledochostomy when conditions are suitable.

Whatever be the indications for cholecystectomy, whether it be done primarily or as a second stage after cholecystostomy, it is satisfactory as it increases the ratio and the rate of immediate recoveries and assures permanence of relief. These factors are largely determined by the completeness of restoration of function in the belly wall and the reduction of intraperitoneal irritation.

A method of performing cholecystectomy has been found to meet these requirements which is easy in suitable cases and has permitted a reduction in the period of disability that places these operations in the category of an interval appendectomy.

Incision is made over the middle of the right rectus from the costal margin downward far enough to make appendectomy possible. The anterior rectus sheath is divided in the same line. The mesial leaf of the rectus fascia is separated from the anterior surface of the muscle, the

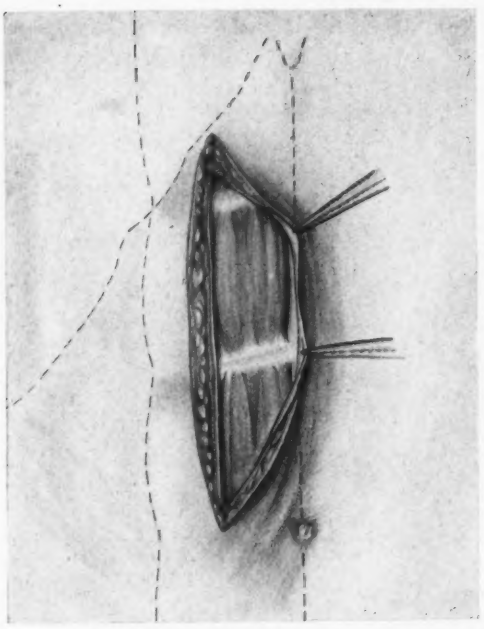

Fig. 1. Anterior sheath of rectus fascia incised, mesial portion reflected to expose rectus muscle.

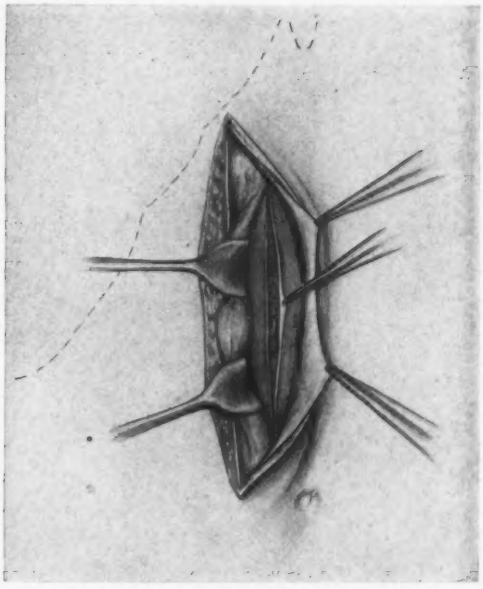

Fig. 2. Rectus muscle retracted laterally, incision made through posterior sheath and peritoneum.

muscular attachments to the midline are broken and the entire muscle retracted laterally (Figs. 1 and 2). The posterior sheath and peritoneum are divided along the line of the original incision. Moist towels are clamped to the peritoneal margins to protect all of the extraperitoneal tissues.

After the intra-abdominal examination has been completed and the appendix removed, the gall-bladder is grasped at the tip of the fundus with a broad clamp and the liver dislocated as favorably as possible.

An incision down to the submucosa is made about the fundus and continued downward along the anterior surface of the gall-bladder to the cystic duct (Fig. 3). A submucous separation of the gall-bladder and cystic duct from the serosa and subserosa is made, largely by blunt dissection. A few branches of the cystic artery require ligation. An excellent blood supply to the serous and subserous coats is assured. The cystic duct, close to the common duct, is ligated using the middle of a long strand of catgut. The duct is clamped distal to the ligature, divided and the gall-bladder removed (Fig. 4).

Removal of the gall-bladder from within outward is possibly more satisfactory than removal from without inward as the cystic duct can be clamped before any considerable pressure has been exerted upon the gall-bladder. Conditions

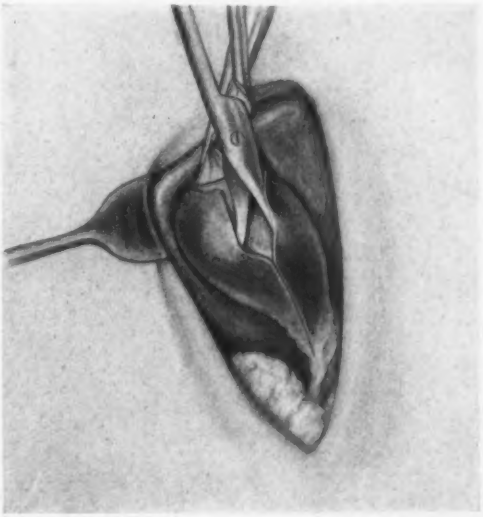

Fig. 3. Incisions down to submucosa of gall-bladder and cystic duct. Submucous dissection begun.

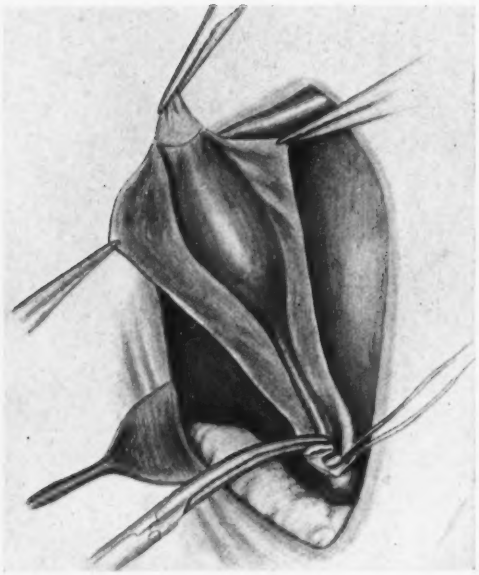

Fig. 4. Submucous dissection nearly complete. Cystic duct ligated, clamped and divided. Serosa and subserosa are not usually divided so far down along the cystic duct as indicated in the drawing, illustrating removal from below upward.

Fig. 5. Submucous dissection completed. Gall-bladder dislocated. Cystic duct ligated, clamped, and ready to be divided. Illustrating removal from above downward when exposure is limited. Usually it is unnecessary to incise the serous and muscular coats as far down as shown for sake of clearness in the drawing.

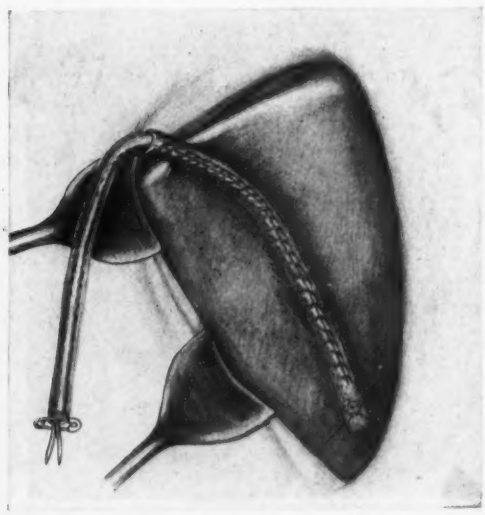

Fig. 6. Drainage tube in position, the inner end pushed over the stump of cystic duct. Serosa and subserosa of gall-bladder closed about the tube excluding injured tissue from abdominal cavity.

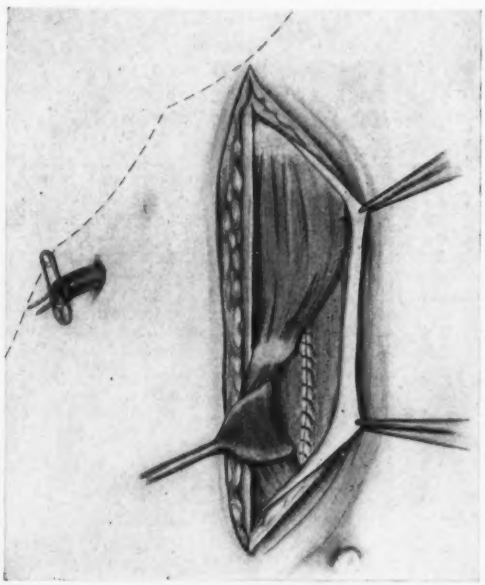

Fig. 7. Peritoneal incision closed, mesial margin of rectus muscle partly sutured in its original position. Drainage tube brought out through lateral incision.

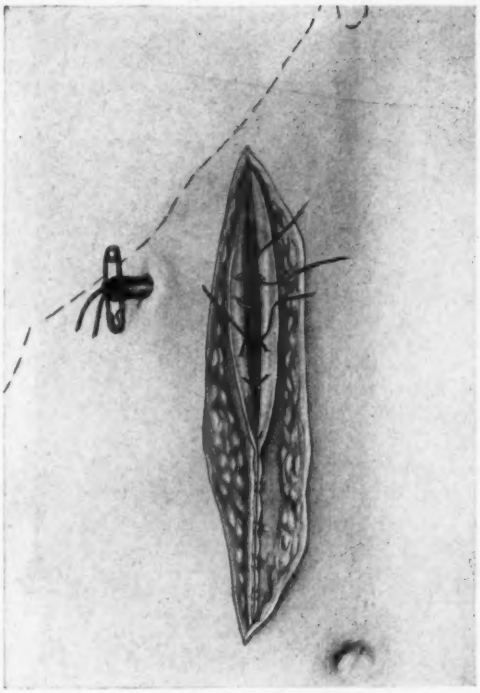

Fig. 8. Method of closure of anterior sheath of rectus muscle with buried silk sutures.

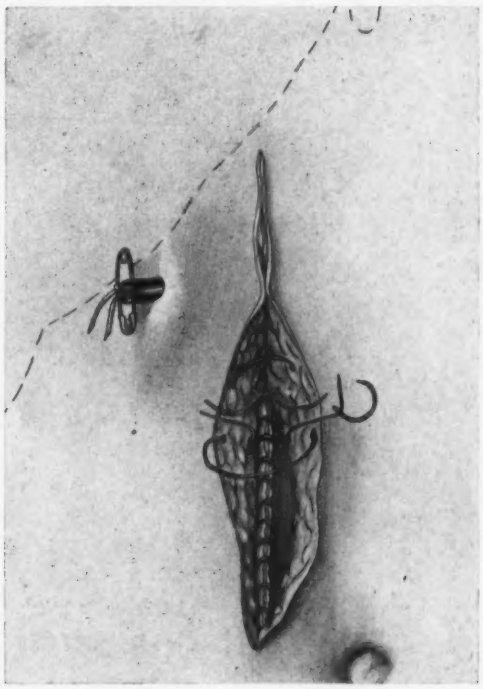

Fig. 9. Rectus fascia approximated by buried silk sutures and accurately closed with continuous catgut. Fine silk stitches being inserted to reunite deep layer of superficial fascia and so as to leave knots toward the deep fascia.

do not always permit of an adequate exposure for this method. Then removal from without inward can be done (Fig. 5). The ends of the ligature are then passed through a small drainage tube which is pushed down *over* the cystic duct stump. A knot properly placed and a safety pin hold the tube in this position (Fig. 6).

The remaining wall of the duct and gall-bladder are sutured so as to make a well-fitting covering for the drainage tube which is usually sufficient even if the gall-bladder has been contracted upon stones, to reach to the parietal peritoneum and to which it may be sutured advantageously. The tube is brought out through a small lateral stab and as there has been no liver damage and no soiling, no other drainage is needed. No attention need be given to placing omentum about the drain; the only deep adhesions will be those due to the irritation of the packing gauze used during operation and those occurring along the lines of peritoneal suture, both of which are transient if peristalsis be stimulated as promptly as possible after operation.

Closure of the peritoneum should turn outward enough of a welt to extraperitonealize the margins bruised by the towel clamps. Rectus muscle is tacked back to the midline with a few stitches including the tendinous intersections (Fig 7). Proper suturing of the anterior sheath of the rectus fascia is most important. Interrupted stitches of fairly heavy silk are so inserted that none of the suture material appears on the external surface, and when they are tied the incised margins are both approximated and everted (Fig. 8). These are then whipped over with continuous catgut. This method of closure gives more than the re-inforcement provided by silkworm-gut and the sutures do not have to be removed in 7 to 10 days when support is most needed. The permanent sutures cause no discomfort, and though the superficial wound breaks down do not act as a foreign body; in fact, wounds so closed break down less frequently than when silkworm-gut is used.

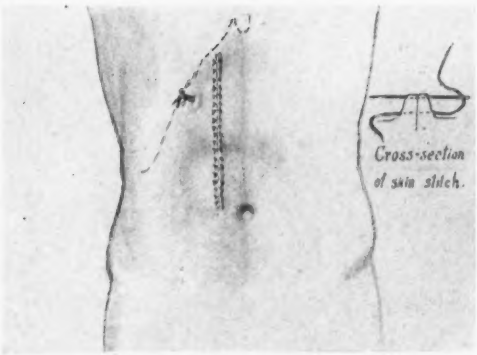

Fig. 10. Completed closure. Stitches to be removed the second day.

The deep layer of the superficial fascia is carefully approximated with fine silk stitches so placed that the knots are toward the deep fascia. There is better healing if this precaution is observed (Fig. 9). The skin is closed with interrupted stitches (Fig. 10) to permit an easier egress of serum which is further favored by a dressing of gauze soaked in warm glycerine. If the superficial loop of the skin stitch be made to include the skin margins as devised by Dr. R. E. Morter and illustrated in the diagram in Figure 10, the tendency of one margin to become inverted is prevented. The more exact approximation and better healing obtained by this stitch amply repays the few minutes added time required for its insertion.

This method of closure permits the removal of skin stitches after 1 or 2 days, which in turn promotes better healing and leaves no stitch scar. It is merely an adaptation of Cushing's scalp suture.

Even obese individuals may be allowed to sit up as soon as they desire and to be out of bed in a few days. If the rubber tube be shortened daily after the first dressing, the parietal sinus will not be troublesome.

ARTHROPLASTIC OPERATIONS WITH REPORT OF CASES OF ARTHROPLASTY OF THE TEMPOROMAXILLARY JOINT, ALSO OF THE ELBOW-JOINT[1]

By A. A. KERR, M.D., Salt Lake City, Utah
Surgeon, Holy Cross Hospital

ARTHROPLASTY or making a movable out of an ankylosed joint is one of the triumphs of modern surgery. The operation consists in separating the ankylosed ends of the bones in the joint by means of a saw and chisel and interposing between the divided ends of the bone and joint a layer of fascia or soft tissue. The cut end of the bone should be sawed or chiseled off to correspond to the contour of the joint. Bony prominences and scar tissue should be removed, tension on the end of the bone should be relieved; all parts of the synovial membrane involved in the process of articulation, which is covered by adhesions and has lost its synovial character, should be covered with the transplanted tissue. One of the most satisfactory methods (advocated and described by the late J. B. Murphy) consists in cutting out a pedunculated flap of fascia and fat near the joint and swinging it between the bones to cover the rough bone surfaces. This flap is sutured in place with fine plain catgut sutures, to the capsule of the joint. Some fatty tissue is desirable in this flap. Muscle and fat may be used if fascia is not available. After about 10 days, passive motion may be begun, the patient being advised and encouraged to use the joint.

An arthroplastic operation, if aseptically done on a joint not infected, may be expected to give a good result. A new synovial membrane is formed and a fluid resembling synovial fluid is secreted. A fibrous layer becomes attached to the end of the bone.

Ankylosis may be fibrous, bony, cartilaginous, ligamentous, capsular, or extra-articular due to contractions of soft parts such as tendons, muscles, and fascia. W. S. Henderson and G. B. New classify their cases into: (1) the articular type in which the joint alone is involved; (2) the extra-articular type; (3) the articular-extra-articular type in which the etiology of the ankylosis is both within and without the joint.

Etiology. Infection, either by continuity or through the blood, and traumatism are the usual

[1] Read before the Western Surgical Association, Kansas City, December 5-6, 1919.

causes. In my cases there was a history of infection. On account of the lapse of time it is usually difficult to secure a very clear history as to the etiological factor. Blair gives trauma as a frequent cause (50 per cent) of ankylosis of the mandible.

Pathology. Lack of development of the mandible takes place if ankylosis of the jaw occurs before the fifteenth year, the teeth, owing to disuse may be poorly developed, and where scars exist due to infection they prevent the natural mobility of the muscles.

Diagnosis. Bony ankylosis allows practically no mobility, while with the fibrous variety there may be a slight motion of the joint. Roentgenograms assist some in the diagnosis, but they must be studied in connection with the clinical history and the physical findings.

Treatment. In arthroplasty of the temporomaxillary joint, a curved L-shaped incision, beginning about 2 inches above and 0.5 inch in front of the ear and down to a point about opposite the external auditory meatus, then anteriorly for about 1.5 inches, is made.

Care must be taken to avoid the facial nerve, the internal maxillary, and superficial branches of the temporal arteries. The condyle of the mandible may be sawed off with a chain saw or removed with a chisel gouge, care being taken not to injure the internal maxillary artery. If the coronoid process is involved, a sufficient amount of it should be resected to permit free motility. A flap of temporal fascia is inserted, and the wound closed with catgut and horsehair or fine silk to avoid an extensive scar.

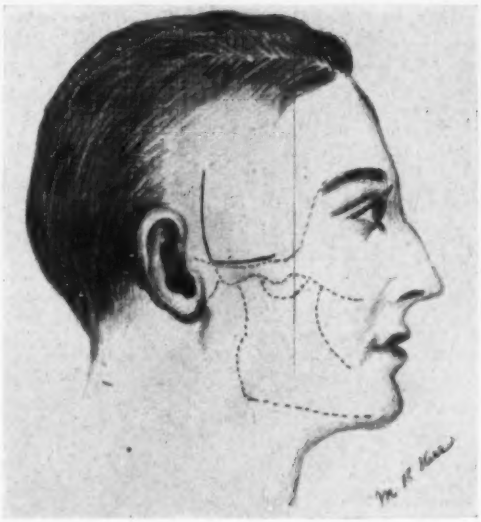

Fig. 1. Incision for arthroplasty of the right temporomaxillary joint.

Henderson and New advise against the use of any fascia, fat, membrane or any foreign material between the ends of the mandible and the temporal bone.

The patient should be encouraged to use the jaw as soon as practicable after the operation, but too powerful attempts at opening the jaw must be avoided, as in some of these cases the teeth are easily broken or displaced. Some of the

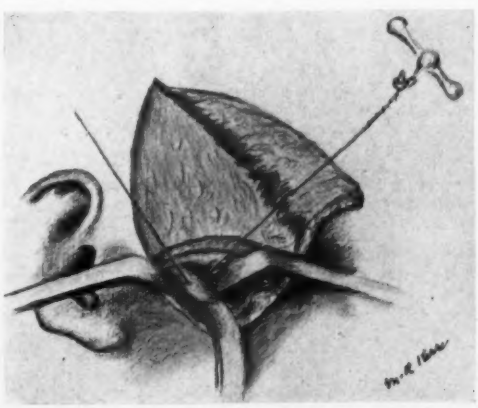

Fig. 2. Joint exposed and method of removing bone in arthroplasty of the temporomaxillary joint shown.

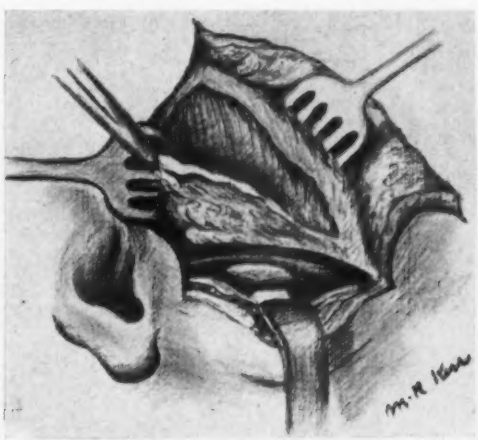

Fig. 3. Method of incising flap of fascia over temporal muscle for inserting over sawed surface of bone.

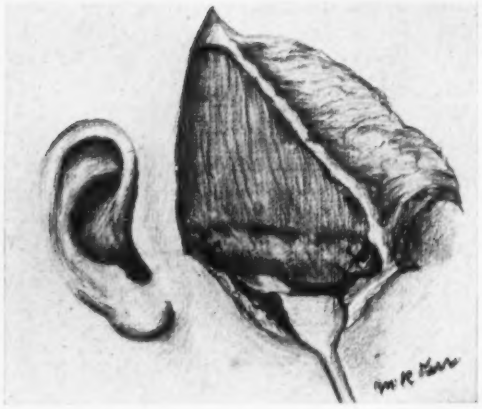

Fig. 4. Flap of fascia inserted in joint and sutured with fine catgut ligatures.

important points to be remembered in arthroplasty of the temporomaxillary joints are: (1) avoidance of injury to the facial nerve, the temporal artery, and the internal maxillary artery; (2) removal of enough bone to give free motion (about one-half inch space between the bones); (3) persistent passive motion as soon as practicable after the operation.

HISTORY OF CASES

Case 1. Mr. X, age 21. Family history negative. In 1910 the patient suffered from what he described as inflammatory rheumatism, involving nearly all the joints of his body, and for about 8 months he was unable to work on account of the pain and weakness. He developed an endocarditis. The inflammation localized in the maxillary joints and for 9 months he has been unable to open his mouth more than one-sixteenth of an inch. There is a distinct aortic regurgitant murmur over the precordia.

There is present a fibrous and bony ankylosis of both joints of the mandible with contraction of the peri-articular muscles and fascia. Roentgenograms were taken by C. W. Stewart. Arthroplasty of both temporomaxillary joints was done, using the technique previously described. Result: The patient was able to masticate solid food after leaving the hospital, but had to guard against subsequent contractions of the muscles of the mandible.

Case 2. Girl, age 16. Family history, negative. The patient has had good health up to 2 years ago, when she hurt the side of her face. Following the injury she had an abscess of the right side of her face, near the parotid gland. Her family physician attempted on four different occasions forcibly to open the mouth.

The patient could not open her mouth, except for a distance of one-fourth inch at the widest place. The lower jaw was only partially developed. Otherwise she appeared fairly well nourished. She has a webbed condition of the fingers, which involves both hands. Diagnosis: Bony ankylosis of the right temporomaxillary joint.

Under warm ether given by Dr. Wilson, the author assisted by C. A. Nyvall, did an arthroplasty of the right temporomaxillary joint, using the technique as previously described, a flap being taken from the fascia of the temporal muscle. Result: Patient is able to open her mouth normally and to masticate her food naturally, and is very happy and grateful.

Fig. 5. Location of incision in arthroplasty of the right elbow-joint.

Case 3. A young man had a complete ankylosis of the right elbow, due to arthritis. At operation an angular incision was made beginning at the external supracondyloid ridge 1.5 to 2 inches above the line of the joint extending downward to the head of the radius and from there along the outer border of the anconeus to the posterior border of the ulna, about 3 inches below the tip of the oleocranon, then curving inward. The first part of the incision extended down to the outer border and external condyle of the humerus, between the supinator longus and radial extensors anteriorly and to the edge of the triceps posteriorly. Below the external condyle it passed down to the bone between the extensor carpi ulnaris and the outer border of the anconeus and divided the strong capsule over the head of the radius, together with the annular ligament at its attachment to the ulna. The lower end of the incision divided the lower end of the anconeus subperiosteally. The incision (Kocher's) fell accurately along the interval between the muscles supplied by branches of the musculospiral nerve and those supplied by the posterior interos-

seous, thus preventing subsequent muscular atrophy. The outer head of the triceps, together with the periosteum and the upper attachment of the capsule was detached from the humerus and the anconeus from the back of the ulna, the attachment of the triceps from the tip of the oleocranon and the flap displaced to the inner side. The external lateral ligament, with the attachment of the extensor tendons and the capsule attached to the external condyle, were separated subcortically and retracted. This enabled one to dislocate the forearm inward. The internal lateral ligament was separated subperiosteally along with the muscles from the inner border of the ulna and the internal condyle of the humerus. The ends of the bone and the diseased tissue were removed, preserving as far as possible the contour of the joint. Some peri-articular fascia was inserted. The wound was then closed.

The result following this technique gave a useful movable joint with no atrophy of the muscles.

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CATHETER RETAINER

BY B. H. CAPLES, M.D., NEW YORK CITY
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THE usual methods of securing an indwelling catheter such as tying it in place by means of threads tied to strips of adhesive, to a spica bandage or to the suprapubic hair have proved, in my hands, to be troublesome in application and unsatisfactory in that the proper adjustment is difficult to maintain. Probably the method most in use at the present time is that of binding the catheter with adhesive strips that run parallel with the shaft of the penis which in turn are held in place by a strip of adhesive surrounding the penis. The objections to this method are that the portion of the plaster surrounding the catheter becomes wet with urine or pus, loses its grip and fails to hold the catheter in place and the fact that this type of retention apparatus is not elastic. These objections are in a measure overcome by the rubber basket-like retainer, made in France, that buckles around the penis. This, too, is unsatisfactory in that the strap surrounding the penis is narrow and produces too great constriction if drawn tightly enough to keep the retainer in proper position. Besides it is difficult to obtain and comparatively expensive.

With these difficulties in mind I have devised a retainer that I have found to be most satisfactory. It consists of two rubber bands one-quarter of an inch in width and seven inches in length. These are crossed in the middle at right angles. A disc of thin rubber one-half inch in diameter is placed on each side and the bands vulcanized at this point. A hole, No. 10 French, is punched in the center (Fig. 1). Through this hole a pair of thumb or small artery forceps is passed about one-half inch, opened gently and the catheter (lubricated) grasped by the tip and drawn through to a point corresponding to the meatus (Fig. 2). The catheter and retainer are then sterilized.

After passing the catheter (Fig. 3) the retainer may be readjusted if necessary. The foreskin, having been carefully dried, is retracted and one turn of a strip of adhesive plaster, one inch wide and twelve inches long, is placed just proximal

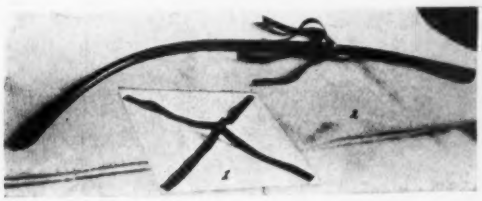


Fig. 1, inset, and Fig. 2.

Fig. 3.

Fig. 4.

to the sulcus. The arms of the retainer are now drawn up one at a time, with gentle tension, parallel to the shaft of the penis and secured in place by a second turn of the adhesive. They are now turned downward and again secured by a third turn of the adhesive which should be firmly but not too tightly applied. The retainer may be used without retracting the foreskin but this as a rule is less satisfactory.

The glans should be sponged several times daily if there be any urethral discharge and if this be marked, as sometimes occurs from the mechanical irritation of the catheter, the catheter should be removed every forty-eight hours and the urethra irrigated. If possible, a period of rest of at least several hours should intervene before it is reinserted. If the adhesive is removed with care and the retainer cleaned with gasoline it may be sterilized with the catheter and used a number of times in succession.

Although an opening of No. 10 French will accommodate the average catheter, the retainers are being made with openings of several sizes. The catheter should be firmly grasped by the retainer but not so tightly that the lumen is more than slightly occluded. If properly adjusted the catheter will not slip and owing to the elasticity of its arms the retainer tends to adjust itself to varying conditions.

In the female this same type of retainer may be used in conjunction with a T bandage, a small hole, through which the catheter passes, being cut in the bandage and the arms being secured to the bandage by safety pins or sewing.

A disc of rubber, about 5 centimeters in diameter, cut from automobile inner tubing and with a hole punched in the center through which the catheter passes, also makes a satisfactory retainer. It may be secured to the T bandage in like fashion.

A CLINICAL STUDY OF OPEN REDUCTION OPERATIONS OF FRACTURES OF THE LONG BONES WITH TWO NEW BONE CLAMPS

By J. SHERMAN WIGHT, M.D., Brooklyn

THE development of the open reduction operation of recent fractures started soon after the discovery of the X-ray. The patient could then obtain a picture of the repaired bone. He often expressed his dissatisfaction with the result. The closed method could no longer hide failure and it became embarrassing to the surgeon to find the fragments out of line or ununited.

Experienced men were able to get surprisingly accurate knowledge of the relation of the broken

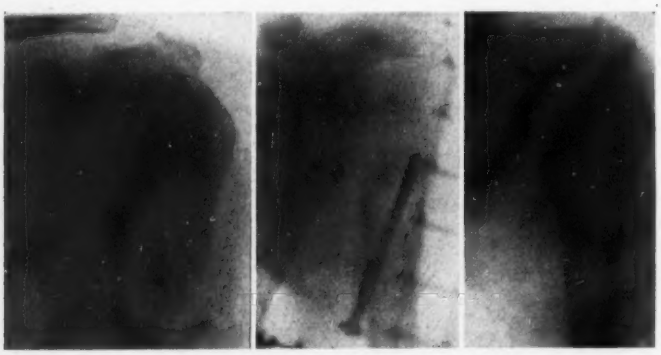


Fig. 1. Fig. 2. Fig. 3.

Fig. 1. Fracture of the surgical neck of the femur.
Fig. 2. Long screw in place securing fragments of bone.
Fig. 3. Result 4 weeks after operation.

Fig. 4.

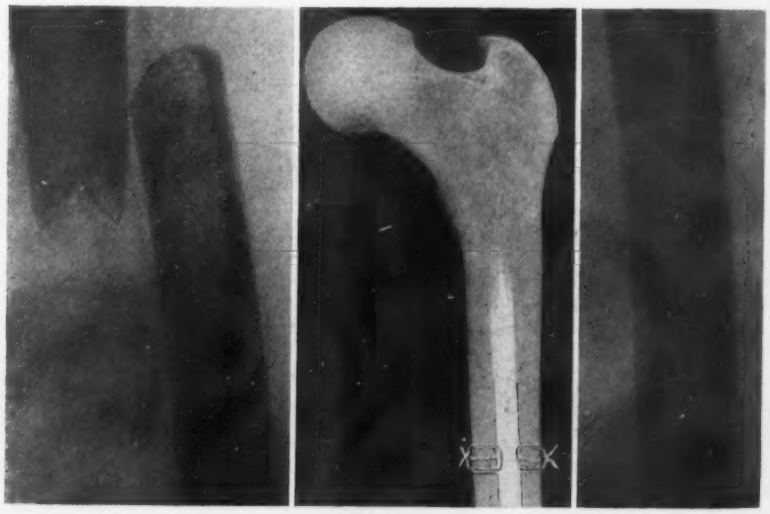
Fig. 5.

Fig. 6.

Fig. 7.

Fig. 4. Oblique fracture of the femur.
Fig. 5. Author's bone clamp.

Fig. 6. Same case as in Figure 4, showing screws in place.
Fig. 7. Result of operation, same case as Figure 4.



Figs. 8, 9, and 10. Transverse fracture of the femur, showing method of tying sutures, and result.

Fig. 11. Fig. 12. Fig. 13.

Fig. 11. Compound fracture of the humerus with osteomyelitis.
Fig. 12. Wound closed after drainage and disinfection.
Fig. 13. Firm union of fracture shown in Figure 11.

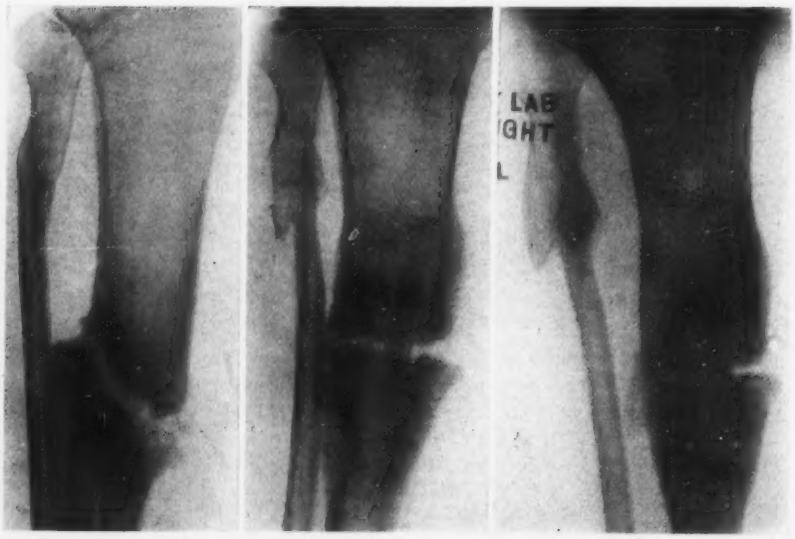


Fig. 14. Fig. 15. Fig. 16.

Fig. 14. Old fracture of the tibia with fibrocystic disease of bone and non-union following osteomyelitis.

Fig. 15. Graft secured with bone pegs.
Fig. 16. Result.

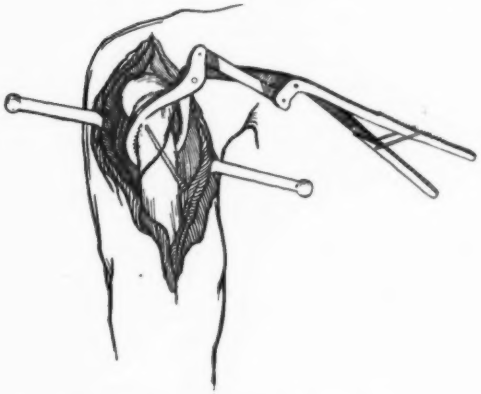


Fig. 17. Author's angular bone clamp.

fragments by the older methods of examination. The more accurate knowledge obtained at the present time by the X-ray relates to displacements, but the same difficulty of replacing and retaining the bone in proper alignment by the closed method remains. Many surgeons rely entirely on the X-ray for diagnosis and to verify position.

There are two kinds of lesions caused by a fracture; one of structure and the other of function. The failure of reduction may make the functional lesion permanent. Function can be restored in the presence of deformity. Pressure from splints, tight bandages, and injury to vessels and nerves at operation may cause a loss of function even if the structural result is perfect.

It is the first duty of the surgeon to restore function. This is determined largely by his ability to replace fragments and the care he uses to avoid pressure or injury to important structures. The X-ray has shown frequent failures and operators have demonstrated the impossibility of reducing many fractures by the closed method, so it may be said that a recent fracture of a long bone suggests an operation.

No operation should be performed until operability is carefully determined. Operability is concerned with the extent of bone injury, reaction from local damage, presence of acute or chronic disease, presence of bone disease, presence of recent infection or old foci of infection, and the ability to repair bone. Small detached fragments separate and cause sinuses by necrosis. Bone cavities cause chronic sinuses. Cancer may be present in bone and cause spontaneous fracture. Syphilis and tuberculous disease of bone contra-indicate immediate operation.

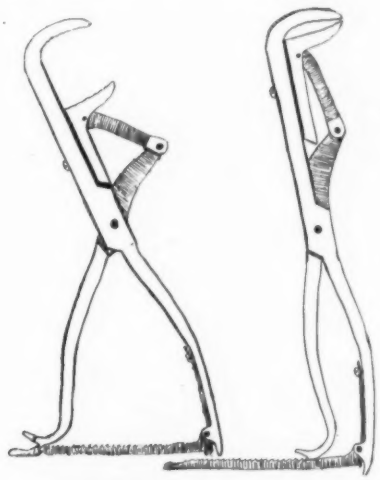


Fig. 18. Author's bone clamp.

All cases that resist correction of conditions that cause a low operability must be treated by closed reduction. Those cases that pass the operability test require great care in exposing the broken ends of the bone. Certain well-recognized lines of approach should be followed in making incisions. They are made where the bone is most superficial and so as to avoid injury to vessels and nerves or unnecessary destruction of tissue. Table I gives the best lines of approach to the long bones.

TABLE I

Humerus	Upper end — Incision along the anterior margin of the deltoid.
	Upper third — Incision between the pectoralis major and the deltoid.
	Middle third — Incision along the outer edge of the biceps continuing upward between it and the deltoid. The brachialis muscle lies on the bone mesially to the deltoid insertion.
	Lower third — Incision splitting the triceps posteriorly and deep dissection. Ulnar nerve is back of internal condyle.
	Lower end — Incisions vertically from condyles upward; the soft parts are separated from anterior and posterior aspects of the bone through these incisions.
Radius	Head of radius — Incision vertically splitting aponeurosis of origin of extensor digitorum communis from behind at the external epicondyle.
	Neck of radius — Incision dividing and retracting the supinator.
	Upper third — Incision superficially to lateral side of extensor digitorum communis — deeply between extensor longus pollicis and extensor carpi radialis brevis extended upward from middle third. The muscles on the back of the arm are retracted mesially.
	Middle third — Same as upper third incision.
	Lower third — Incision between brachioradialis and extensor carpi radialis longus.
	Lower end — Incision between insertion of brachioradialis and radial artery.
Ulna	Subcutaneous from end to end — inner posterior aspect.
Femur	Hip-joint and neck—Incision from anterior superior spine of the ilium to the great trochanter then backward in the direction of the ischial tuberosity. Incisions either anteriorly or posteriorly to the sartorious muscle carried vertically.
	Upper shaft — Vertical incisions anteriorly or posteriorly to the sartorious muscle carried downward.

TABLE II

Bones Injured		No. of Operations	Average Age	Male	Female	Recent Injury	Old Injury	Compound Fracture Comminuted	Bone Disease	Syphilis and other Diseases	Acidosis Corrected with NaOH	Suture	Screw	Bone Peg	Inlay Bone Graft	Lane Plate	Average time of removal of Screw (weeks)	Average time of Union in Recent Injury (weeks)	Average time of Union in old Injury (weeks)	Bony Union	Fibrous Union	Non-Union	Deformity	Limp	Bone Infection	Wound Infection	Embolus	% Mortality
Humerus	Upper Extremity	52	17	41	11	47	5	0	0	0	27	0	51	1	0	0	3	4	5	52	0	0	0	0	0	0	0	0
	Shaft-Transverse	8	21	8	0	8	0	0	0	0	1	4	0	0	4	0	0	5	0	8	0	0	0	0	0	0	0	0
	Shaft-Oblique	10	18	9	1	8	2	5	0	2	6	0	5	0	0	5	3	14	15	10	0	0	1*	0	5	5	0	0
	Lower Extremity	12	13	10	2	7	5	1	0	0	3	0	5	0	0	7	3	12	5	12	0	0	4	0	1	1	0	0
Radius	Shaft-Transverse	3	30	3	0	3	0	0	0	0	0	3	0	0	0	0	0	4	0	3	0	0	0	0	0	0	0	0
	Shaft-Oblique	7	28	7	0	6	1	0	1	5	2	3	4	0	0	0	3	4	7	7	0	0	1	0	0	0	0	0
Both Bones	Shafts Transverse	15	20	15	0	9	6	4	2	2	3	9	0	0	2	4	0	10	12	15	0	0	8	0	4	4	0	0
	Shafts Oblique	5	29	4	1	5	0	0	0	0	2	2	3	0	0	0	3	5	0	5	0	0	0	0	0	0	0	0
Ulna	Shaft-Transverse	2	18	2	0	2	0	0	0	0	0	2	0	0	0	0	0	4	0	2	0	0	0	0	0	0	0	0
	Shaft-Oblique	3	20	3	0	3	0	0	0	0	0	3	0	0	0	0	0	4	0	3	0	0	0	0	0	0	0	0
Femur	Shaft-Transverse	22	25	20	2	21	1	3	0	0	5	18	0	0	1	3	0	10	0	22	0	0	0	0	3	3	0	0
	Shaft-Oblique	42	26	34	8	28	14	5	3	1	12	0	37	0	0	5	4	12	18	41	0	0	5	2	5	5	1	1
Bones of the Leg	Tibia-Transverse	7	24	7	0	7	0	2	0	3	0	0	0	0	5	2	0	10	0	7	0	0	0	0	2	2	0	0
	Tibia-Oblique	34	29	32	2	20	14	8	14	3	10	0	4	0	22	8	3	11	33	34	0	0	10	15	8	8	0	0
	Fibula-Transverse	7	24	7	0	7	0	2	0	3	0	5	0	0	0	0	0	10	0	7	0	0	0	0	2	2	0	0
	Fibula-Oblique	34	29	32	2	20	14	3	2	3	10	20	0	2	0	0	0	10	25	34	0	0	10	15	3	8	0	0.
Totals		263	x	231	29	201	62	33	22	22	81	69	101	3	34	34	x	x	x	262	0	0	39	32	31	38	1	.45

Upper two-thirds — Incision along a line drawn from the tip of the trochanter major to the outer border of the patella.
Lower third and lower end — A vertical incision from either or both epicondyles. From abductor tubercle for popliteal space.

Tibia Subcutaneous from mesial tuberosity to tip of malleolus.

Fibula Incision through posterior peroneal septum along lower subcutaneous surface.

Figure 1 shows a fracture of the surgical neck of the humerus with the common displacement upward, forward, and inward of the proximal end of the distal fragment. The overriding is irreducible. My open reduction operation for this fracture is done through an incision along the mesial border of the deltoid. It is carried down to the bone, and the soft tissues are retracted so as to expose the surgical neck.

The fragments are replaced and grasped in my angular bone clamp (Fig. 17). A hole is bored obliquely upward and inward through the proximal fragment into the head of the bone to receive the long screw shown in place in Figure 2, which secures them. The clamp is removed and the wound is closed in layers, burying the screw. It is important carefully to suture the muscle sheath. A light shoulder cap splint is applied fixing only the shoulder-joint. The arm is held in a sling. Passive motion from the elbow down is started immediately. The screw is removed at the end of 3 weeks and motion of the shoulder-joint is begun. The shoulder splint is left off at the end of 4 weeks with the result shown in Figure 3.

Figure 4 shows an oblique fracture of the femur. This fracture is spiral if one component of the breaking force is tangent to the long axis of the bone. It is irreducible when muscle gets between the ends. My open reduction of this fracture is made through an incision on a line drawn from the great trochanter to the lateral border of the patella. The bone is superficial and is reached with little damage to the muscles. The fragments are replaced on a fracture table with the aid of extension and grasped in my clamp shown in Figures 5 and 18. Two holes are drilled transversely through both fragments to receive the screws shown in Figure 6 which secure them.

The clamp prevents the fragments from being separated by the screws. It is removed and the wound is closed in layers burying the screws. The sheath of the muscle is carefully sutured, the

limb is put in plaster from the foot to the waist. The screws are removed at the end of 4 or 5 weeks and the muscle sheath is again carefully sutured. Passive motion is begun. The result is shown in Figure 7.

Figure 8 shows a transverse fracture of the femur. The fragments are displaced with overriding and are irreducible by the closed method. My open reduction operation of this fracture is done through the same incision as for the oblique. The fragments are drawn out of the wound. Their ends are drilled transversely, and two heavy chromic catgut sutures are passed through from one to the other on opposite sides of the canal. The fragments are replaced, so that they fit end-to-end and the sutures are tied firmly in the manner shown in Figure 9. The wound is closed in layers with the muscle sheath carefully sutured. The entire limb is encased in plaster. The cast is removed and renewed in 3 weeks. It is left off when union is strong and gives the result shown in Figure 10.

Figure 11 shows a recent compound fracture of the humerus with osteomyelitis. The first step in this open reduction is a free incision with removal of necrotic tissue and detached fragments of bone. Drainage and disinfection are continued until the infection is under control. Then the fragments are fixed in position with a Lane's plate. The plate is removed as soon as the bone will stay in line. The drainage and disinfection are continued until the wound closes, Figure 12. There is loss of bone and frequently bone cavities with firm union as shown in Figure 13.

Figure 14 shows an old fracture of the tibia with fibrocystic disease of the bone and non-union following osteomyelitis. The open reduction of this fracture is through a vertical curved incision over the tibia making a lateral flap. The entire diseased section is removed cutting through healthy bone. A long graft is taken from the other tibia and inlaid deeply. The fibula is shortened in order to bring the cut ends of the tibia together and the graft is secured with bone pegs, Figure 15. The wound is closed and a cast applied to fix two joints. Figure 16 shows result.

I have chosen these descriptions of open reduction operations because they illustrate five important fractures. They occur frequently and therefore offer an opportunity for surgeons to agree on some standard procedure for their treatment. The precepts outlined have been carefully carried out in the operations given in Table II.

Open reduction cases are selected with great care. Those that are rejected are poor subjects and some will not stand violent efforts at closed reduction. Firm splints and bandages will cause ischæmic paralysis. The surgeon should advise these patients that he can obtain a fair result and may get deformity with some loss of function.

CONCLUSIONS

Fractures of the long bones with displaced and overriding fragments are seldom reducible by the closed method and suggest open reduction.

Operability must be determined in all cases.

No operation should be undertaken in acute disease or infection.

Chronic disease or infection must first be treated and may reject operation.

Arrested local disease foci in bone must be excised through healthy tissue without disturbing their contents.

Operation should be delayed about 2 weeks in recent injuries.

No operation should be performed with carbon dioxide combining power of the blood below 40 cubic centimeters. This capacity should be raised in all cases before operation with an intravenous injection of sodium hydroxide.

Small detached fragments must be removed at operation.

The fragments of a recent oblique fracture of a long bone should be fixed with screws.

The fragments of a recent transverse fracture of a long bone should be sutured by my method.

Fracture of the surgical neck of the humerus should be fixed with a screw.

Fragments of the radius, ulna, and fibula are best secured with sutures.

Oblique fractures of the lower end of the humerus with displacement are irreducible by the closed method, and the fragments are best secured with a Lane plate placed posteriorly.

The fragments of all compound fractures should be fixed with a Lane plate or Smith's clamp and the wounds opened wide for drainage and disinfection.

All screws and plates should be removed as soon as the fragments will remain without their support.

Old fractures of long bones with non-union should be united with long inlay grafts.

Bone cavities with chronic sinuses are cured by breaking down their walls and implanting bone or muscle to fill them up.

APPARATUS FOR IMPLANTATION OF RADIUM EMANATION POINTS

By ROBERT M. LEWIS, M.D., Baltimore

IN treating certain types of malignant tumors with radium, the implantation of minute capillary glass containers filled with emanation is more efficient than is any form of surface application. If the growth is found on the surface of the body or at a point that is easily reached, the introduction of the emanation is a simple matter. The emanation, or active gas given off from the radium, is transferred by a mercury pump into a fine capillary glass tube about 3 to 4 millimeters long, which is then sealed, sterilized with alcohol, and placed in the end of a sterile, hollow needle for introduction into the malignant growth. The needle, acting as a carrier for the emanation point, is now plunged directly into the tissues to the desired depth, and the glass point or spicule is then dislodged with an obturator or stilet of wire and the hollow needle carrier is withdrawn, completing the little operation. As a rule, such a minute glass particle does not act as an irritant but remains harmlessly imbedded in the tissues after the emanation has spent itself, which takes place in the course of a few days. Only a small amount of emanation—say from 2 to 5 millicuries (1 millicurie is the equivalent of a milligram of radium) is implanted in each spicule.

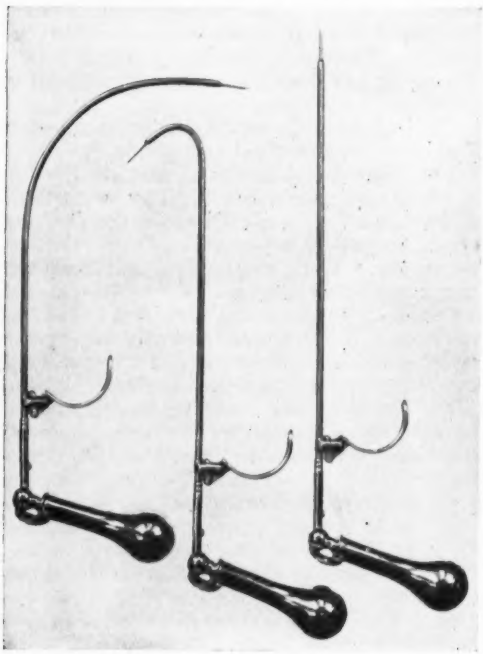


Fig. 1.

To demonstrate the comparative efficiency of surface and implantation treatments, a patient with lymphosarcoma, whose entire body was covered with subcutaneous nodules of disease, was recently treated. Two masses, each about half the size of a hen's egg but nowhere near each other, were chosen for the test. The one was treated by the introduction of a 4-millicurie point, the other in the more usual way with nearly 4 grams of radium held at 1.5 inches from the tumor for 20 minutes. In five days' time both masses were about one-fourth their original size. A month later only a very little induration, representing the original tumors remained.

Growths in certain sites, for example those in the bladder, thorax, or the nasopharynx, are difficult to treat effectively and with precision and perfect accuracy by direct surface application of packages or by the usual instruments for implantation. For such cases I have found it necessary to devise special instruments, which would work through a cystoscope or around corners involving different curves. It was simple enough to have made the straight instrument shown in the photograph. The construction of the curved ones, I found more difficult.

The straight instrument is used to implant in bladder tumors. The larger curved instrument is designed for laryngeal work, while the remaining one is arranged to treat tumors in the nasopharynx. In each a stilet is attached to the trigger to push its (the end of the stilet) end out flush with the end of the needle, thus forcing out and imbedding the emanation in the tissue. Before using the apparatus, alcohol sterilization is sufficient. The tiny emanation containers are laid in the hollow needle in front of the plunger. A little sterile vaseline on the needle point prevents the contained point slipping out accidentally.

TRANSACTIONS OF SOCIETIES

CHICAGO SURGICAL SOCIETY

JOINT MEETING OF THE CHICAGO SURGICAL AND CHICAGO NEUROLOGICAL SOCIETIES, HELD JANUARY 2, 1920, DR. CHARLES E. KAHLKE, PRESIDING

FALSE ANEURISM OF INNOMINATE ARTERY

DR. A. E. HALSTEAD: Thomas F. Kielty, Corporal, Co. M., 168 Inf., was injured September 12, 1918. While in action in the Toul Sector, the patient ran forward and was hit by a machine-gun bullet. The machine gun was about 600 yards in front of him. The bullet entered the patient's neck about 4 centimeters above the sternoclavicular junction and 3 centimeters to the right of the median line; it left his body through the back at the junction of the third and fourth dorsal vertebræ, 4 centimeters to the right of the median line. He fell, did not lose consciousness, got up, and then walked back 1 mile. Immediately after the injury, his neck began to swell, his voice became low, and he expectorated a small quantity of blood during the first 3 days after the injury.

On admission to Base Hospital No. 68, on September 16, examination showed a swelling of the neck in the region of the thyroid gland and resembling it in outline. The swelling was greater on the right side than on the left. There was a slight bruit over the right side of the swelling. The neck was stiff, deglutition difficult; he was able to swallow only very small particles of solid food; inspiration was difficult, the voice was weak and low; there were diffuse ecchymoses on the upper chest; slight pain; no paralysis; urine negative; white blood cell count on September 26, 16,550.

The patient's chief complaints were (1) difficult breathing; (2) almost complete loss of voice (examination of larynx on September 23 showed a paralysis of the abductors of the right vocal cord); (3) swelling and stiffness of neck (circumference of neck over point of wound, 58 centimeters).

Operation on September 26. The patient was asphyxiated at the time he entered the operating room. An incision was hurriedly made over the most prominent part of the tumor. Violent hæmorrhage followed. The index finger was introduced and the opening in the vessel found. It was on the superior surface of the innominate artery close to the origin of the carotid, and was about half the size of a dime in diameter. The clots were evacuated. The hæmorrhage was controlled temporarily by the finger in the vessel and by means of pressure. The inner end of the clavicle was disarticulated and 2 inches of clavicle resected. The upper end of the sternum for 1.75 inches was removed with rongeur forceps. The wound was sponged dry. No. 0 chromic catgut sutures were used to close the opening in the vessel.

The postoperative condition has been favorable; there has been gradual improvement in health, and the patient's voice is regaining its power slowly. About November 10, 1918, he was out of bed, having regained his former strength and full power of voice.

In the literature only 2 cases are to be found in which, because of injury to the vessels close to the innominate artery, ligature or suture of the innominate artery was resorted to. Of these, one was a stab wound of the inferior thoracic artery and one a gunshot wound of the common carotid artery. Both of these were treated by ligature of the innominate artery and both died. For wounds of the innominate artery itself 3 cases are reported: 2 followed by immediate death and 1 by death on the eleventh day. In none of these was surgical interference attempted.

The first case was reported by R. H. Harte.[1] E. I. colored, laborer, age 26, admitted to Pennsylvania Hospital, May 31, 1896. The patient had received a pistol shot wound in the neck, the shot being fired from a distance of 4 feet. The shot entered the neck on the left side 1 inch above the level of the clavicle. A probe entered 1.75 inches. The patient could not move the left arm.

An incision was made on the right side of the neck, posterior to the sternomastoid. The ball was found in a pus pocket, close to the œsophagus behind the carotid artery and just above the origin. On the third day food regurgitated through the wound; on the eleventh day there was a hæmorrhage. The wound was packed. On the thirteenth day there was a hæmorrhage. The innominate, subclavian, and carotid arteries were ligated. The internal jugular vein ruptured and was ligated. Death followed in a few hours. Autopsy showed ulceration of the œsophagus and cervical vertebræ, abscess of the right temporosphenoidal lobe and right frontal lobe.

The second case was reported by Hutin.[2] N. C. soldier, wounded in the right axilla by scissors

[1] Harte, R. H. Ann. Surg., 1897, xxvi, 489.
[2] Hutin. Lancet, 1841-2, ii, 230.

blade A severe hæmorrhage was stopped by packing. The packing was removed the same day. On the fourth day there was another hæmorrhage, which was stopped by packing. There were three hæmorrhages during the following 8 days. On the twelfth day the patient had a violent hæmorrhage with pain in the axilla. Pressure on the axillary artery controlled the hæmorrhage. The subclavian artery was tied. The patient remained well for 5 days. In straining at stool on the sixth day, the subclavian ligature came away and hæmorrhage followed. The innominate artery was ligated. Death on tenth day. Autopsy showed only inferior thoracic artery injured.

The third case is reported by E. W. Walker.[1] J. C. male, admitted to Cincinnati Hospital with gunshot wound above the center of the left clavicle. There was slight ecchymosis about the wound, marked swelling of tissues above the right clavicle, shock, and pain. At entrance there was little hæmorrhage. An ice bag was applied and the patient kept quiet. On the first day temperature developed following a chill. Later the patient coughed but the sputum was not blood stained. On the sixth day erysipelas developed. Death on the eleventh day.

Autopsy showed that the bullet fractured the left clavicle one-fourth inch from the left sterno-clavicular articulation; lodged at apex of the right pleural cavity, three-fourths inch above the upper border of the first rib, one and one-half inch from the costovertebral articulation. There was a wound, three-fourths inch long, one-fourth inch wide, of the innominate artery one-fourth inch below termination on posterior aspect. The wound was closed by a clot one-fourth inch thick by 1 inch wide, extending into subclavian and carotid arteries. The right lung was completely collapsed from effusion.

A fourth case was reported by L. R. Erwin.[2] The patient had a stab wound one-half by three inches. The weapon entered transversely above the right sternothyroid muscles and divided the innominate artery in two-thirds of its diameter, close to the bifurcation. The wound extended through the trachea and œsophagus and terminated one-fourth inch in the body of a cervical vertebra. There was hæmorrhage through the incision, mouth, and nose. The author quotes another case similar to this. In this instance the man walked 30 yards before falling. Death.

SYMPOSIUM ON PERIPHERAL NERVE INJURIES

Dr. G. Carl Huber, Ann Arbor, Michigan, read a paper on "Repair of Peripheral Nerve Injuries." (See p. 464.)

Dr. Lewis J. Pollock read a paper on "The Clinical Signs of Nerve Injury and Regeneration." (See p. 472.)

[1]Lancet-Clinic, Cincin., 1881, vii, 49-51.

[2]Erwin, L. R. Am. J. M. Sc., 1872, lxiii, 281.

DISCUSSION

The discussion was opened by Dr. Dean Lewis, who presented the "Surgical Aspects of Peripheral Nerve Injuries."

SURGICAL ASPECTS OF PERIPHERAL NERVE INJURIES

Dr. Dean Lewis: I believe that I can best illustrate the points that I wish to emphasize by demonstrating different types of nerve injuries which have been operated upon.

This patient was wounded in the Argonne Forest, October 27, 1918. A shell exploded near him, wounding him in four places. The internal condyle of the left femur was removed, a large wound over the outer and posterior aspect of the left shoulder was excised, a fragment of high explosive entered the posterior surface of the sacrum, and the right musculospiral nerve was divided about 3 or 4 inches above the elbow-joint. The musculospiral nerve was sutured on February 21, 1919. Two tension sutures of catgut were placed through the nerve, and the epineurium closed with fine catgut. Approximately 4½ months after the nerve was sutured, there appeared the first evidences of return of motion. This was associated with marked hyperæsthesia of the skin supplied by the musculospiral nerve. I believe that this may be regarded as a complete return of function, for the patient can place the palm of the hand forward, with the little finger adjacent to the seam in the trousers leg with all the fingers extended and in line. This is only possible when the supinators, the extensor communis digitorum, and abductor longus pollicis function.

This man was wounded in Belgium during the first week of November, 1918. He passed through Evacuation Hospital No. 5, having sustained a machine-gun-bullet wound of the right arm which did not fracture the humerus. Dry dressings were placed upon the wounds of exit and entrance. Both of these healed rapidly. The musculospiral paralysis which came on immediately has not improved. When the musculospiral nerve was exposed, it was found divided and driven into a hole in the bone which the bullet had evidently perforated without fracturing. After the ends of the nerve were exposed, the scar tissue was resected, and an end-to-end union by means of epineural sutures was made.

Within 5 months after suture there was a decided return of motor power. This is most marked in the radial extensors of the wrist. Extension of the fingers is still limited and there has been little if any return in the abductor longus pollicis.

An interesting thing about this case is that a neuroma through which regeneration has occurred developed at the point of suture. A distinct neuroma painful upon pressure can still be felt, but it is decidedly smaller now than a few weeks ago.

The next patient was wounded in the Argonne Forest. He sustained a compound fracture of the

left humerus near the middle. This was accompanied by a musculospiral paralysis. He was operated upon April 15, 1919. When the nerve was exposed in the musculospiral groove a relatively large sequestrum was found in the humerus. This was removed; tincture of iodine applied to the cavity; and an end-to-end suture of the nerve made after the neuroma and scar tissue had been resected far enough back to permit of herniation of healthy appearing neurofibrillæ. The wound was then closed. Much to my surprise healing by first intention occurred. Within the last two weeks there has been a decided return of motor power. He is now able to extend the wrist and when flexion of the forearm is attempted the supinator longus is thrown into action. The first evidences of return of motor power were noted 2 weeks ago.

This patient was also wounded in the Argonne Forest. A machine-gun-bullet entered the anterior axillary fold low down, and made its exit over the triceps muscle posteriorly. The musculospiral nerve was divided on the inner side of the arm before it enters the groove. It was sutured April 22, 1918. Return of motion was noted approximately 5½ months after suture. One night the patient put his hand outside of the bed clothing and attempted to extend the wrist. Much to his surprise he found that he could move it. This was the first evidence of return of function.

This patient was wounded in the Argonne. He sustained a fracture of the left humerus (machine-gun-bullet) accompanied by a paralysis of the musculospiral nerve. It was impossible to determine by clinical examination whether there was a physiological or anatomical division of the nerve. However, no neuroma could be found along the course of the nerve. The nerve was exposed on the 20th of April, 1919, and was found imbedded in scar tissue and callus. When the nerve was dissected free, it had a frayed appearance. Four funiculi, however, passed from the upper to the lower segment. It was thought inadvisable to attempt resection because these funiculi were intact and if resection were attempted, it would be difficult to make an end-to-end suture. Muscle neurolysis was, therefore, performed. He now has return of motor power in the extensors of the wrist; and beginning return of power in the extensor communis digitorum. There is still no return of power in the extensor longus pollicis.

This patient has a large scar upon the inner surface of the left arm in the upper third. He presented the typical picture of combined ulnar and median nerve palsy when first examined. The nerves were exposed on March 18, 1919. There was considerable lymph œdema of the arm. Both nerves were divided and the ends separated by a considerable distance. After mobilization of the nerves, an end-to-end suture was performed.

There was noticed shortly after the operation considerable improvement in the appearance of the hand. There has been, as you can see, almost complete return of function of the muscles supplied by the median nerve. Flexion of the fingers is almost complete. The atrophy of the thenar group of muscles is not so marked and there is distinct return of power, which is increasing rapidly, in the opponens pollicis. It is also interesting to note that in this case a neuroma can be palpated at the point of suture in the median nerve.

This patient was wounded in the Argonne Forest on September 22. He sustained a high explosive wound of the tarsus of the left foot and of the posterior surface of the right thigh, the sciatic nerve being completely divided. An end-to-end suture of the sciatic nerve was performed on March 19, 1919. A defect of 7.5 centimeters was overcome after the nerve ends were mobilized and the knee flexed to a right angle. The knee was kept in this position 4 weeks before any attempt was made to straighten the leg. Even then the leg was extended gradually. He first noted return of motion in the muscles of the calf 6 weeks ago. Distinct contraction can now be felt, but the muscles supplied by the external popliteal nerve are still paralyzed. The atrophy of the leg is much less marked, and the function in the group of muscles just mentioned improves rapidly.

This next patient was wounded October 5, 1918, and presented the symptoms of a complete sciatic lesion. He was operated upon July 30, 1918. The sciatic nerve was exposed, but was not found divided. A muscle neurolysis was performed. There are now distinct evidences of recovery of motor power in the muscles of the calf, and there is also some evidence, not marked, of return of motor power in the anterior group of muscles.

This patient sustained an injury of the ulnar nerve, which was divided. An end-to-end suture was performed July 1, 1918. The flexor of the little finger is still paralyzed, but I think that there are distinct evidences of return of function in some of the small muscles of the hand. The general appearance of the hand is much better.

The best results after suture have been obtained in the musculospiral, the median and sciatic. There are evidences of return of function in some cases in which the ulnar nerve has been sutured. There has been return of function in but one case after suture of the external popliteal and in this case return of motion, which was almost complete, was noted after 5 months.

I wished to present three cases of causalgia, but it has been impossible to get these patients because they have left the hospital. These three patients were cured by intraneural injection of 60 per cent alcohol. In two cases the median nerve was injected and in one the internal popliteal and long saphenous nerves. This procedure is so simple and the results are so satisfactory that it is to be preferred to periarterial sympathectomy advocated by Leriche. Whenever neurolysis is attempted in causalgia, it should be combined with intraneural injection of 60 per cent alcohol. Neurolysis alone does not control the pain in many cases and even

in those in which there is some relief, it is apt to be but temporary and the pain may recur with the same or greater severity.

In performing nerve suture the neuroma and scar tissue should be resected far back. The resection should be carried far enough back to permit healthy appearing neurofibrillæ to herniate. Hæmorrhage should be controlled, so that a dry field is maintained. When the suture is completed the epineurium should be closed so that the neurofibrillæ cannot stray or scar tissue invade the line of suture. The suture should be made with little or no tension. After the suture is completed the nerve should be placed when possible in a new muscle bed. The dissection should be made when possible along intermuscular septa so that the muscle fibers of these muscles which may later be needed to form the new bed for the nerve are not cut. It is not necessary to use any of the numerous methods to cover the suture line which have been advocated.

Neurolysis is an operation which is of distinct value. It may be combined with capsulectomy and parallel incision of thickened epineurium in certain types of cases. Muscle neurolysis is, I believe, the best operation. In this operation an attempt is made to place the freed nerve between healthy, nonbleeding muscle. The dissection must, therefore, be made when possible along intermuscular septum. I believe this method preferable to neurolysis by fat, fascia, Cargile membrane, or formalinized calves' artery.

Where the defect is so long that end-to-end suture cannot be performed, the auto-cable transplant, which has been tried out so satisfactorily and convincingly by Dr. Huber, is the operation of choice. I believe that I have two cases in which there are decided evidences of return of function after the use of the auto-cable transplant.

Dr. Ernest Sachs, St. Louis, Missouri: One point should be mentioned and that is that the handling of nerves is a very different sort of thing than that we are perhaps accustomed to employ with other tissues of the body. A nerve must be handled with great gentleness when it is to be sutured; second, what in my experience is very important, the nerve should be kept warm and not permitted to become chilled, which is accomplished by wrapping it up in hot cotton during the period of operation which is usually a long and tedious one.

The only phase of the work on which I have had any experimental experience confirms absolutely what Dr. Huber has said, namely on the use of fat. It was first described by Rehn who emphasized its great value in applying it over defects in the brain. Some eight years ago I tried that out experimentally and became convinced that his observations were absolutely wrong; that the fat was completely replaced in a short time by a dense mass of connective tissue, and in several cases in which I applied this clinically, I had an opportunity later on of opening the wound again and found that the same thing had occurred.

One point that Dr. Pollock brought out of the many interesting ones he presented is the emphatic way in which he showed that it is impossible to tell whether a nerve is anatomically or physiologically divided. That seems to me a valuable contribution. So frequently in articles and in textbooks men seem to beat around the bush on that subject. What he said about the length of time after which a nerve may still regenerate is a statement that I do not question, but one that might lead to faulty treatment surgically. Even if it is possible for a nerve to regenerate 7 or 8 months after an injury, I do not believe it is advisable to wait as long as that before determining whether or not the nerve is absolutely divided. If Dr. Pollock believes that, I must take issue with him. If the evidence is present that the nerve is completely blocked, I believe the proper procedure is to explore the region of the injury and determine the nature of the block, and, if necessary, take steps then to correct it.

What he had to say about the time of recovery of a nerve I do not wish to discuss with him because he has this very large material, but anybody who has busied himself for a long time with neurology cannot help but feel a little disconsolate, when a certain thing we have banked on for many years has been undermined; in other words, certain props have suddenly been knocked from under one. I refer particularly to what he said about the work of Head in regard to peripheral nerve disturbances. His evidence is extremely interesting, it is difficult to contradict, but it seems to me has not absolutely refuted the work extending over many years of Head and his various co-workers. I do not quite see how he explains the return of sensation, for example in the ulnar anæsthetic area by the overlap, for, it seems to me, that if the overlap controls a large part of that area, the overlap ought to be present immediately after the injury. In other words, the only anæsthetic area ought to be the exclusive area supplied by the ulnar nerve. As I understand his observations, and I have read his article on the subject, there is a wider loss of sensation at first and after a short time some sensation returns in that area due to the overlap. I cannot quite see why the anæsthetic area from the very beginning should not correspond to the exclusive area supplied by the ulnar nerve as he has worked it out.

Dr. G. Carl Huber (closing): I can readily see that there may be an apparent overlap in sensory areas more than is generally recognized. The sensory nerve supply for a particular area, for instance, the peripheral ulnar field, need not be exclusively supplied by the ulnar; other bordering nerves may be educated in the course of a few weeks to give perception from the borders of the same area. I am confident that it is not necessary in practical work to give undue stress to Stoffle's studies on the specific funicular structure of nerves. Any one who has worked experimentally with regeneration of nerves realizes that from 10

to 50 new neuraxes may bud toward the periphery from a single central neuraxis, and 15 or 20 new neuraxes are often found centrally in a single old neurilemma sheath. No matter how carefully primary suture is made, there is a great tangle of these new nerve fibers as they pass through the connective tissue of the wound, and especially is that the case with secondary sutures. A large number of fibers pass from the stump along the transplant in the connective tissue surrounding the transplant. I am sure, sensory nerve fiber branches reach the motor nerves; and that central motor nerves reach the distal sensory nerves and are maintained for a time. They make no distal connection and in time degenerate. I am confident there is never complete regeneration of the peripheral stump, and to some extent there needs to be re-education of the nerve centers after every regeneration of the peripheral stump. The anatomic findings often give very distinct motor and sensory recovery without full functional return.

DR. POLLOCK (closing): In reference to the first criticism of Dr. Sachs, I believe that with certain reservations it is well taken. I did not wish to be understood as saying that operative procedures were contra-indicated within a period of from 8 to 9 months following the injury. What I meant was that if an injury of a peripheral nerve which had produced a complete physiological interruption was spontaneously recoverable, it was a mistake when operative interference was instituted to perform a resection and suture, even if 8 or 9 months had elapsed from the time of injury. Such procedures as exploratory operations and neurolyses were by no means contra-indicated.

It is impossible to discuss at length the question of the function of nerve overlap in a limited space of time. However, I might point out several facts: First, although the work of Head and his coworkers has been accepted fairly largely in ordinary physiologies and is a matter of common acceptance among many neurologists, yet recent studies have shown that this work is not incontrovertible. Second, some recent physiologies are bold enough to throw some discredit upon this work. I maintain that the dissociated and relatively early return of sensation to pin prick is not due to a supposed early and miraculous regeneration of protopathic fibers, but to the assumption of algesic function of adjacent and overlapping nerves.

The extent of this overlap can be determined by establishing the extent of residual sensibility. Residual sensibility is that sensibility remaining in an area of skin when all the nerves adjacent to the one being studied have been severed. For example, if we have a combined lesion of the internal saphenous and the internal popliteal, what sensation is left can be supplied only by the external popliteal. If, therefore, the web between the toes and that part of the sole adjacent to the web is sensitive to pain under the above condition, the external popliteal nerve supplies this area through its overlap. If the median, ulnar, and musculocutaneous nerves are severed, that part of the palm which is sensitive to pain must receive an overlap supply from the radial. No return of pain sense within an area of possible overlap of an adjacent nerve can be attributed to regeneration unless touch sense returns as well.

It is evident that if sensation has returned on the radial part of the palm after an injury to the ulnar and median nerves, and if these nerves subsequently be resected and sutured and the sensibility still remain, this sensibility cannot be due to any regeneration of these nerves. Why sensibility to pain within an area of nerve overlap does not appear immediately following injury of an adjacent nerve can only be determined by psychophysiological investigations. The fact remains that this sensibility returns gradually and subsequent section and suture does not affect it.

It seems to me that, if we find this return of pain sense only in the areas which we have shown to be parts of the residual sensibility of adjacent nerves, that if this sensibility never appears if the adjacent nerve be injured at the same time, that this sensibility disappears if the adjacent nerve subsequently be sectioned and, finally, that this sensibility is not affected by subsequent section and suture of the injured nerve, my point that this return of sensation is not due to regeneration, is proven.

CORRESPONDENCE

ISTITUTO ORTOPEDICO RIZZOLI, BOLOGNA

NOTICE OF CONTEST

To the Editor:—The contest for the Umberto I prize has been opened. A prize of 3,500 lire will be awarded, in accordance with the decision of the Provincial Council of Bologna, for the best orthopedic work or invention. Italian and foreign doctors may enter the contest. Arrangements for the contest and for the assignment of the prize are explained in the regulations, a copy of which will be sent upon request. Applications for admission in the contest should be made to the President of the Rizzoli Institute in Bologna. The contest will close December 31, 1920.

Bologna, Italy. G. ZANARDI, *President.*

EDITORIAL

SOUTH AMERICAN SURGEONS

THEODORE ROOSEVELT, with characteristic courage and vigor, overcame all opposition and caused the Panama Canal to be built. The dream of nearly five centuries was realized. The whole world is forever Roosevelt's debtor. By the severance of the land connection between North and South America these two continents are now united as never before. The long, hazardous routes of travel of the olden time have been replaced by new ones, safe and speedy. The great war came so quickly after the completion of this epoch-marking achievement that it has not as yet touched Pan-American imagination.

Having returned recently from a trip to South America where, in company with Dr. Franklin H. Martin, I visited some of the important surgical clinics of Peru, Chile, Argentine, and Uruguay, where we became acquainted with and observed the methods of many surgeons, I take this early opportunity to pay merited homage to these men of science, learned in surgery. It is but just to say that in their hospitals and operating rooms they are the equal of any representative group from any country in the world. They have that intuitive clarity of thought and facile mastery of technique which we associate, and rightly, with the French and Italian schools. The surgeons of South America have recognized for a long time the necessity of frequent clinical trips to observe the work of foreign surgeons; of late years many of them have come to the United States; it has been always a pleasure to know them.

Their medical schools are splendid institutions with a seven-year course, and are the equal in equipment and methods of theoretic teaching of any in the world. In South America "Commencement Day" means just that, for after graduation the young surgeon begins a special course of surgical training. Instead of carving his way to knowledge and experience by the scalpel, he is tutored for a period of from eight to ten years along lines which we of the United States have accepted only recently under the general term of fellowships in graduate medicine and surgery.

The hospitals of South America are imposing, built for the tropics, and associated with the medical schools. The hospital records are the best I have ever seen; this is true of every hospital we visited, small or large.

The reception given us by our South American confrères was most cordial, and we came away with not only admiration for the South American surgeon as a surgeon, but also with a feeling of personal friendship for him that will last for life. Whatever may be the after-war responsibility of the United States abroad, we can not question that our first duty is to develop a sound Pan-Americanism.

A Pan-Americanism of science, a unity of the spirit and ideals, will be more lasting than measures based on financial, commercial, or political considerations.

William J. Mayo

SOUTH AMERICAN SURGEONS

A Trip in Behalf of the American College of Surgeons by Dr. William J. Mayo, President, and Dr. Franklin H. Martin, Secretary-General.
Jottings of the Secretary-General—Continued

By FRANKLIN H. MARTIN, M.D., F.A.C.S.

I. ACTUAL SURGERY

"WHAT about the surgery you witnessed?" This is the question most frequently asked. Unfortunately, we had but one or two opportunities to see the surgeons at work. One morning, in the course of hospital inspection, we saw three operators at work in as many institutions. The first surgeon was operating on an ectopic pregnancy, in which a primary rupture had occurred, and the patient was exhausted by the serious hæmorrhage. The operation was skillfully performed. In another operating room the surgeon was doing a careful dissection on a strangulated inguinal hernia, under a local anæsthetic. An eight-inch, gangrenous intestine was revealed. The operation was ably managed under surroundings that were perfectly safe, although the operator was undoubtedly surprised at finding himself the observed of the premier surgeon. In a neighboring hospital we witnessed an appendectomy. A gangrenous appendix was removed in the routine way. The morning's observation revealed surgery equal to that of the best hospitals of New York City, Chicago, and Rochester.

In other cities we witnessed parts of procedures, and in each instance the surgery was apparently of the highest class. I am quite sure that Lima, Santiago, Valparaiso, Buenos Aires, or Montevideo could entertain a surgical society of the United States or Europe and give a surgical demonstration that would reveal a broad experience, approved facilities for diagnosis, recognized technical ability, and a fundamental knowledge of surgery that could not be excelled anywhere.

II. PANAMA

It is now well recognized that the Panama Canal could not have been completed if it had not been for the sanitary regulations that were devised and enforced in connection with the work of digging and constructing. The Medical Corps of the United States Army was responsible for this accomplishment. This Corps, through the self sacrifice of its members, revealed the course of malaria and yellow fever, and discovered and applied the remedy. The miracle of the completion of the Panama Canal could not have been attributable to Theodore Roosevelt alone even if it had been necessary to occupy much more territory; nor to General Goethals alone even if the Culebra slides had been multiplied ten times; but to that lovable man who, with his associates of the Medical Corps of the Army, applied the rules of modern sanitation, rules based on fundamental discoveries, and administrative regulations formulated by this same great scientist, Major General William C. Gorgas.

III. MAJOR GENERAL WILLIAM C. GORGAS, M.C., U.S.A., RETIRED

One does not wonder that General Gorgas loves the beautiful spot that his genius made possible, and that he saw rise from a tropical jungle of pestilence to a paradise for men—the destined garden spot of the world.

Once while General Gorgas and the writer were waiting for an interview in the office of the Secretary of War, we spoke of the horrors of the war in which we were both so busily engaged. I remarked to the General that it must seem to him that fate had pursued him pretty closely; after all the work he had done in sanitation to be suddenly called upon to raise an army of civilian doctors for the greatest war of history. "Yes," he said, "I wish the horrible war were over." I said, "What is the very first thing that you would do, General Gorgas, if tomorrow morning, before arising, you should receive a telephone message assuring you that the war was ended?" "Do you know what I would do?" he asked, while his eyes had a far-away, wistful expression. "I would ring off, call New York City, and order a passage for South America. I would go to Guayaquil, Ecuador, the only place in which yellow fever is prevalent, exterminate the pestilence, and then—and then return to Panama, the garden spot of the world, and end my days writing an elegy on yellow fever."

And this was not the mere day-dreaming of a man overwhelmed by a stupendous job, but the real yearning of a peace-loving man, who, within a month after the armistice, accepted a commission from the Rockefeller Foundation to go to Guayaquil, Ecuador, to do the very job that he wished to do.

While Dr. Mayo and I were visiting the President of the Republic of Peru, he spoke affectionately of General Gorgas and said that three of the South American Republics—Peru, Ecuador, and I believe Colombia—had appointed General Gorgas the official Inspector-General of Sanitation for the western coast. Unfortunately, we missed General Gorgas at Panama, as he was on his way south and we had passed each other en route without realizing it.

IV. SEÑOR JAVIER PRADO

We were afforded the pleasure of visiting Señor Prado at his palatial home, with its private museum containing antiquities of the ancient Peruvians and of the Incas of the pre-Peruvian age. Señor Prado is a son of a distinguished Peruvian who was President of the Republic at the time of the last war between Peru and Chile. He has gathered one of the most complete collections of ancient Peruvian pottery now in existence. Many rooms of his home are filled with unusually beautiful coco bolo and mahogany carvings. His art gallery contains some of the finest works of Peruvian painters. He has collected from France and Italy excellent bronzes, marbles, miniatures, cameos, and fans. One of the sleeping rooms is a marvel with carved furniture and cabinets of native coco bolo and mahogany, while the polished floors are covered with some of the most perfect Vicuña rugs that we saw in South America. From the windows one viewed the patio, which is a particularly artistic feature of this palace which is situated in a country where tropical gardens of great beauty are seen everywhere. An interesting room is one which contains many busts and the family portraits, a number of which are likenesses of his illustrious father in the gorgeous uniforms of his time with many decorations. Señor Prado is a most charming host, and he is extremely modest in exhibiting his treasures. One of the marvels of his collection is a room filled with the skulls of Inca chiefs, many of them having been distorted and reduced by cunningly devised pressure apparatus used by these aborigines. The Señor's secretary brought two of these precious skulls to Dr. Mayo and myself at our hotel in Lima. These are mementos that we shall prize forever as reminders of an enjoyable visit to a most interesting man.

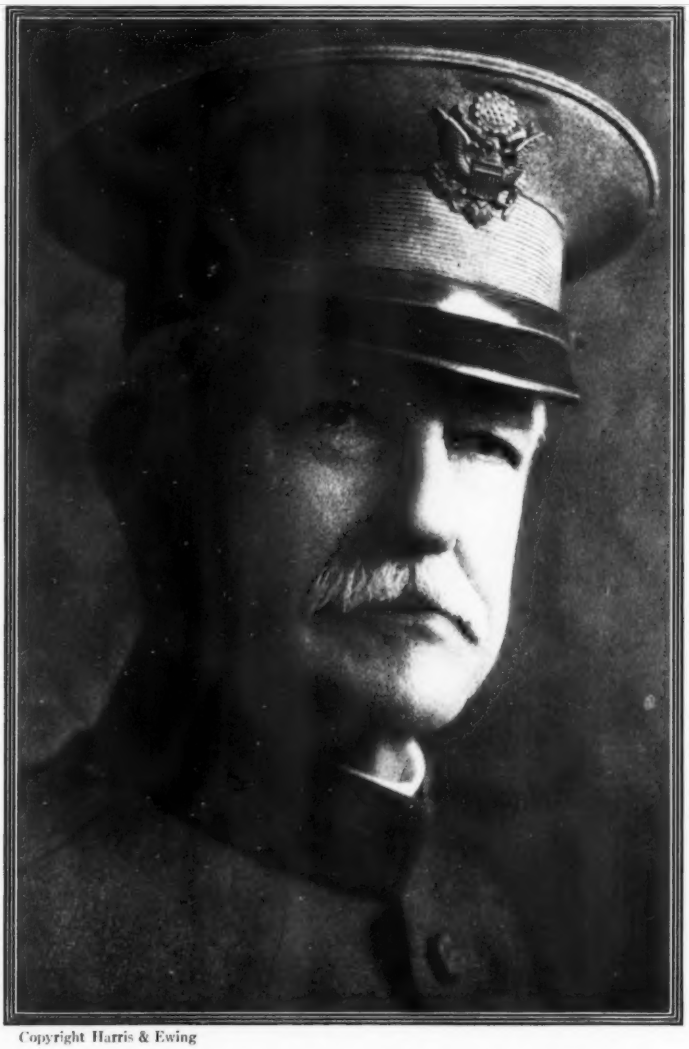
V. HONORARY FELLOWSHIPS

Honorary Fellowships in the Sociedad de Cirugía del Perú were conferred upon Dr. Mayo and myself, under interesting auspices. The ceremony occurred in the main lecture room or amphitheater of the Medical Department of the University of San Marcos. This university, by the way, was established just one hundred years before the founding of Harvard University, making it by far the oldest university on the two American continents.

We assembled in the main lecture room, on the large platform of which were the members of the Sociedad de Cirugía and of the Faculty of Medicine of the university. The President, Dr. Juvenal Denegri, occupied a seat at the center table, with Dr. Mayo and myself at either side. Flanking us were the members of the Faculty and of the society. On the main floor or amphitheater were about two hundred students. The back of the amphitheater opened onto a court filled with tropical plants, palms, and flowers. This could be seen through an attractive colonnade which outlined the assembly hall. The students, a splendid group of young fellows, were in their places when we entered and filed onto the platform. They rose in a body and cheered and applauded for several minutes. It was a reception that was rather stirring, and warmed our hearts to the future medical profession of Peru.

The President, Dr. Denegri, read an address of welcome to the two candidates for Honorary Fellowship. In the meantime, we had received copies of the English translation of the address. A second address was read by the Secretary of the Association, Dr. Francisco Grana. The Honorary Fellowships were then separately conferred by the President, and engraved parchment certificates presented to us as evidence of this honor.

As Dr. Mayo rose to speak, he received an ovation from the Faculty and students that plainly deeply touched him. It was some time before he was allowed to express his pent-up feelings and to say to them how much we appreciated their great hospitality and especially the honor they had just conferred upon us. He then described the object of our visit to South America. My own talk was received with an enthusiasm that I was at a loss to understand. In responding, the most I could do was to congratulate everybody on something: the splendid body of students for being educated in the oldest university on the Western Hemisphere, in a medical school with a seven-year course; the Faculty for being privileged to teach in the university, with such an attractive student body; Dr. Mayo and myself for being so fortunate as to be privileged to visit this institution and to receive such a reception. The brief talk was suddenly termi-



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MAJOR GENERAL W. C. GORGAS, M.C., U.S.A. (Retired)
A Builder of the Panama Canal

nated and was followed by the most enthusiastic applause, too much for the conventional and rather commonplace talk. It occurred to me that there was some compensation in being brief and in speaking in an unknown tongue. It transpired, however, that these were not the reasons. It seems there has been quite a partisan controversy in the medical department over the length of the course, viz., the seven-year requirement for a medical degree. This had been discussed pro and con with considerable feeling, the students being divided into two factions, one opposing the long course and the other upholding it. In congratulating them on the seven-year course, I had used the sign language by holding up seven fingers to emphasize my speech. Each of the two groups to the controversy interpreted my remarks as favoring its contentions; hence the outbreak. As a matter of fact, Dr. Mayo and I soon found that our talks when brief and least understood were most heartily received.

VI. IMPORTANCE OF STANDPOINT

Dr. Mayo, as we all know, is the philosopher of practical surgery. We may not have thought of him as a philosopher-poet, but on a number of occasions on this remarkable trip of ours the claws of practicality were padded, and in the purple atmosphere of the southern continent the poet emerged. "In coming to South America," he said to the Secretary of State of Uruguay, "we have succeeded in changing our standpoint. In our northern continent we live under the polestar, and our whole view is from the standpoint of the northern heavens. Now we have visited and viewed for the first time the heavens of the southern cross, and with this experience our range of vision has been broadened and the expanse of our standpoint has been doubled. In the future, America will mean to us all-America, including that under the polestar, and no less that under the southern cross."

VII. SURVIVAL OF THE FITTEST

How little do we know of the people of the southern continent! We were accustomed to thinking of them as the inhabitants of a number of small republics which would compare in area to so many of the states of our own country. In our ignorance we considered them, of necessity, more or less provincial. Our idea is now changed. Instead of being provincial in their attitude toward life, we found the peoples of South America to be the broadest and most cosmopolitan in the world. And why shouldn't they be? The continent of South America, including the Central American states, was the first to be explored by European countries. Taking Peru as an example, review for a moment its history. It had an ancient civilization that antedated by several centuries the discovery of America. This race was overrun, and after a prolonged struggle it was conquered by armies of Spain, led by the most competent adventurers. With the subjugation of the Incas, the Europeans intermarried with this strong race of natives, and for four hundred years this melting-pot has been fed by the men and women of vision and adventure of Europe—England, France, Italy, Germany, and Holland—and from it has emerged a strong nation of self-reliant Peruvians, which represents the survival of the fittest of centuries of evolution.

And that is how they appear! They are of strong physique, self-reliant in attitude, their strength of character predominates, and they are ambitious for self-education; they are not satisfied to retain a local outlook; they are not as we are prone to be—selfish in our preparation for intercourse with the world; they, most of them, know and cultivate at least two continental languages besides their own; they seek a classical education at home and supplement this with world travel and study abroad; they are people of strong temperament and broad vision, and they are interesting in their social intercourse with each other and with the strangers within their midst who are properly vouched for. And here, in a country that is a paradise of beauty, a wonderful people is pursuing its life, conscious of its worth, and with a world experience that compares favorably with the best of its continental confrères.

And what applies to Peru is equally true of Chile, Argentine, and Uruguay—similar experiences, similar conquests, similar European emigration, similar yearning for independence; fertile land, mountains that are filled with minerals, and climates that attract the lovers of life; these are the ingredients of a melting-pot that has evolved a new people in a new civilization that cannot longer remain unrevealed.

VIII. A DOUBLE CONQUEST OF PERU

From the Log, January 25. A day of rest after three strenuous days of business, pleasure, and interest in Peru. It is Sunday. The festivities are over and the guests have departed. It is in the small hours of the morning; the floors of the deserted halls are still covered with confetti; and the few guests remaining are talking over the triumphs of the party. Strenuous

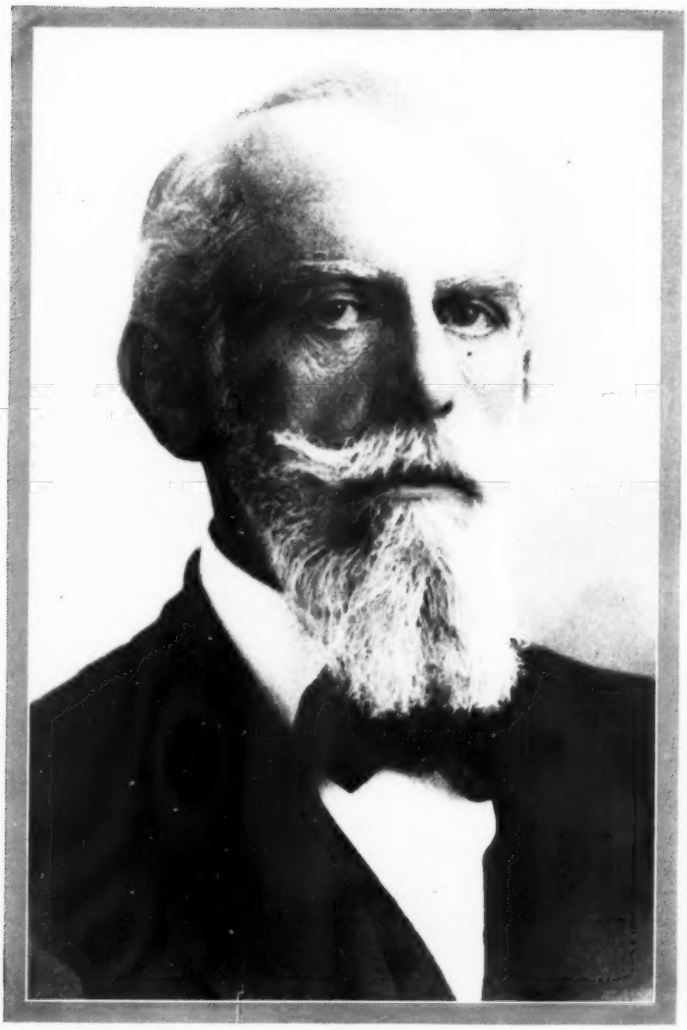
entertainment transpires so rapidly that one fails to grasp all of the thrills of it until he reviews it in retrospect. So with the visit to Peru. The three days spent there will become more and more interesting and important as time goes on. In talking it over, Dr. Mayo and I feel that we have been veritable Pizarros—Dr. Mayo the leader and the rest of us his lieutenants. We have brought down certain ideals and our object has been to reconquer Peru. Our victory is different from the old one in that those whom we came to conquer have outgeneraled their adversaries and conquered us.

And so Pizarro sits this Sunday morning under a white canopy on the deck of his flagship, surrounded by his faithful adherents, and enjoys a day of rest. The coast of the conquered continent is within sight, and over the rugged hills of the shore-line occasionally appear the snow-capped peaks of the second tier of mountains. We are just under the line of the sun on its excursion back from the Tropic of Capricorn, and the rays are perpendicular. But Pizarro and the conquering army care not because the Humboldt current with its cool water from the south pole has also brought a gentle, cooling breeze. So while the church bells in all parts of the world are calling the men and women to worship, and to observe their prosperous neighbors' apparel, we too take stock and give thanks for the wonderful new friendships we have made. But the chief, in his thirst for conquest, is drawing a new line on the map of the continent—a red mark which extends to Chile, Argentine, and Uruguay, and the ship turns its prow in that direction.

IX. DR. MARCELINO HERRERA VEGAS

Dr. Marcelino Herrera Vegas, who is easily the dean of surgery of the southern continent, is a man whom it is an exceptional honor to know. He has the face of a seer, and he possesses a sensitive, æsthetic temperament. He is of a family of distinguished Argentinians, the estate of which dates back to the foundation of the Republic. His town residence is a palace—the repository of works of art in painting, sculpture, literature, and the furnishings of a refined household. His library, with its gallery, is a cabinet of exquisite taste and appropriateness. With his own hands he has cross-indexed and catalogued the contents. The books, all his friends, are clothed in appropriate and substantial bindings, as he would dress his sons and daughters whom he loves. He writes with his own hand his literary contributions and gets recreation by making his own research. When his eyes and brain are tired, instead of playing games, he practices his languages and reviews his poets by writing plays in long-hand and by copying his favorite poems. He has twice written the plays of Shakespeare in long-hand to aid him in perfecting his English. To illustrate some point in conversation, he occasionally quotes to you a thought from an English, German, French, or Spanish poet, and then repeats the exact words with the interrogation: "Do you remember?" And, of course, as a rule you do not. Men of his class seem to have sufficient time in which to crystallize their knowledge, and they have a knack of utilizing their learning without appearing ostentatious. Dr. Vegas would rather know thoroughly the great thought of a master, in order that he might live it, than be the originator of something but little better than the commonplace. We, in rapid-fire America, must seem crude and immature in comparison with the associates of this man who reads his classics, and who has gained for himself a knowledge of the best of the ages. And with it all he is a practical teacher of surgery; he is a skilled operator; he endeavors to redeem the cripples and to save the lives of the poor of Argentine; he is a scientific man in the understanding of his art; he visits hospitals, dresses wounds, is a time-server, follows schedules, and consults time tables. When the summertime has come and he is through with his classes and the day's work is done, he does not employ his time in useless play, but goes to his *hacienda* and lives with the out-of-doors, the companions of his estate, and supervises the cultivation of the land. He watches trees grow that were planted by his grandfather, and he plants trees that will be watched and enjoyed by his grandchildren. This is our friend as we learned to know him—a superb character, a true gentleman, and one who is greatly admired by his confrères.

And this is the type that we met among the professional men of the cities of the four South American republics which we visited. We found a premium placed upon education, a knowledge of the languages, and experience gained in foreign travel. The cultivation of the finer graces is encouraged. The study of art, literature, and music of the highest quality is pursued, and a knowledge of the finer arts is considered essential to good breeding. I wish that all of our friends could know as we do these outstanding characteristics among their maturer men, who are so honored and looked up to by their younger followers and admirers—Gregorio Amunategui, Alberto Adriasola, and Lucas Sierra, of Chile; Marcelino Herrera Vegas, Daniel J. Cranwell,



DR. GREGORIO AMUNÁTEGUI

Professor of Clinical Surgery and Dean of the Faculty of Medicine, University of Chile, Santiago, Chile

and Pedro Chutro, of Argentine; A. Ricaldoni, Enrique Pouey, and Gerardo Arrizabalaga, of Uruguay; and Juvenal Denegri, Miguel C. Aljovin, and Guillermo Gastaneta, of Peru.

X. THE ROMANCE OF A DENTAL COLLEGE

February 13. An interesting diversion this morning was a visit to La Escuela Dental, the dental department of the University of Chile, at Santiago. The Dean, Dr. Jerman Valenzuela, was our host and conducted us through a modernly equipped dental school. This institution has accommodations for three hundred students. Each student has a complete equipment, including a dental chair, instrument cabinets, instruments, supplies, and a laboratory for conducting a scientific clinic in dentistry. The building covers an entire block and is two stories in height. It is comparatively new and splendid architecturally.

Attached to the founding of this department of the university is an interesting romance which involves the supposed murder of a German Consul; the burning of the legation; the mysterious disappearance of the janitor of the building, and of a large sum of money belonging to the Consul's country which had been taken from the safe. A search among the ruins revealed the body of a man, much disfigured, on which were found the shirt-studs, cuff-buttons, and other personal effects of the Consul. The Chilean Government was much humiliated by the atrocious murder, and proceeded to make amends for the tragedy in every possible way. The official received a magnificent burial, and the state vied with the municipality in doing honor befitting the station of the deceased and the country which he represented. During the inquest, Dr. Valenzuela, the dentist, requested the privilege of examining the jaw and teeth. He made careful notes of his findings. He discovered that the murdered man had splendid teeth without fillings or defects, and that one wisdom tooth was missing. He then consulted the wife of the Consul and learned that her husband had had defective teeth and had been the subject of considerable dental repair. The wife of the janitor stated that her husband had had perfect teeth and had consulted a dentist on but one occasion, when he had had a tooth extracted. This information, which confirmed Dr. Valenzuela's suspicion, was communicated to the proper authorities. The investigation that followed led to the capture of the official who had become snow-bound in the Andes in his attempt to escape with his bags of gold. He was brought back to Santiago, tried for the murder of the janitor and treachery to his government, and finally executed. In the meantime, the janitor had received a state funeral. He had been buried with great honor, and his remains placed in a mausoleum, as befitted the rank of an honored official of a great nation. The clearing of the mystery had relieved the Chilean Government of serious humiliation and embarrassment. Attention naturally turned to the unostentatious man who, by careful observation, had been instrumental in clearing up the international disgrace. What could the government do for him? He asked nothing for himself, but suggested that he had long possessed an ambition to build a model dental college for Chile. The Chilean Government asked him to present his plans, and the final result was the establishment of the thoroughly equipped institution that we visited today. We received a hearty welcome from this "Sherlock Holmes," Dr. Jerman Valenzuela, the Dean of La Escuela Dental, who has every reason to be proud of his ideal institution.

XI. A DEMONSTRATION OF EFFICIENCY

The pace for many days had been a fast one. On leaving the dental clinic in Santiago, Dr. Mayo, who is always considerate of his associates, intimated that I was looking rather peaked and suggested that I return to the hotel for a little rest, as our afternoon was to be a strenuous one. This, to me, was a welcome suggestion. The officials accompanying us suggested that they utilize my incapacity to give us a demonstration of their municipal service. The city has developed a personal service organization. Any individual in distress may, in case of injury or sudden illness, call for aid from any public telephone. An immediate response is accorded in the form of an auto ambulance, with a medical attendant. We were fully two miles from the hotel. I enthusiastically consented to become the victim for the experiment. A telephone call was made, and we were asked to time the response. In less than five minutes, considerable commotion was evident in the narrow street, and with a rush an attractive, clean ambulance landed at the curb. A white-coated official conducted me to the coach and placed me upon the couch. The ambulance turned and, working continuously a three-noted siren that could be heard for blocks and which all traffic is bound to respect, started for the hotel and arrived within the prescribed time—five minutes. It was a wild ride, because it was an official demonstration, and the importance of time on this occasion seemed to be thoroughly

appreciated by the attendants. However, we reached our destination without killing or maiming any people or dogs, and without catapulting any cathedrals or corner drug-stores.

The Chileans are a progressive and efficient nation, and this is obvious to the casual visitor. The Chilean Government, Army, Navy and Municipalities all reveal thorough organization, thrift, and administrative ability of the highest order. The little demonstration referred to above was a practical illustration of their attention to detail.

XII. OUR METHOD OF TRAVEL

It was difficult for us to make arrangements by which we could cover the necessary territory and return within the reasonable time limit of not to exceed two months. We, therefore, took advantage of a travel tour which was organized by the American Express Company, and the details of their plan were so generously carried out that we have not regretted traveling in that way rather than independently.

Our ship was the "Ebro" with an English crew and management. This eight thousand-ton, twin-screw steamer was built especially for cruising just before the outbreak of the war. It was thoroughly well-equipped for tropical travel, and possessed luxurious, modern conveniences.

ITINERARY

January 7, Wednesday — Sailed from New York.

January 13, Tuesday — Kingston, Jamaica.

January 16 and 17 — Panama Canal.

January 22, Thursday, to January 24, Saturday — Callao, the port for Lima, capital of Peru.

January 26, Monday — Mollendo, a typical Peruvian port.

January 27, Tuesday — Arica, a Chilean port, popular as a seaside resort. An excursion by rail to Tacna, the "oasis city."

January 28, Wednesday — Iquique.

January 29, Thursday — Antofagasta, the port through which most of the products of the Chilean nitrate fields are shipped.

January 31, Saturday — Coquimbo.

February 1, Sunday, to February 14, Saturday —Two weeks on shore with visits to Valparaiso, Santiago, thence by rail over the Andes to Buenos Aires, LaPlata, and Montevideo, on the east coast.

February 14, Saturday — Returned by rail to Valparaiso.

February 29, Sunday — Through the Panama Canal.

March 2, Tuesday — Another stop at Kingston.

March 8, Monday — Arrived New York.

XIII. OUR HOSTS OF SOUTH AMERICA

The Panama Canal has brought the western coast of South America—Lima, Valparaiso, etc. —within fourteen days of New York City, Chicago, or New Orleans. With a return to normal shipping conditions and a growing acquaintance with our South American people, a merchant marine, by mutual agreement, will soon develop that will make us the closest neighbors. And one needs to visit these countries but once to appreciate the great worth and charm of these neighbors.

We were privileged to make our visit under exceptional circumstances. We were practically official guests; but in the busy times we had an opportunity of sitting at the home tables and getting an insight into South American family life. Everywhere we were charmed. The young men and women, the sons and daughters of our hosts, were interesting to study. In their education they are early trained in the arts, in the classics, and in the languages. The young women cultivate their music, and on a number of occasions we were thoroughly entertained by the daughters of the families playing with unusual skill the classics of Chopin, Liszt, and other composers with thorough ease and enjoyment. The young men are ambitious, and all of the young men and women have either spent a year or two in European travel, or are planning to do so. In their preparation for such travel, they have almost invariably learned English and French. And while in the past they have looked almost exclusively to Europe as their travel ground, they are now talking of America, and this spirit of friendliness and appreciation for the United States is materializing rapidly and nothing will develop their attitude more than visits by us to their countries. We must lay aside our provincial airs and cocksureness, and be willing to broaden out as they have done, learn their language as they have learned ours, and make ourselves worthy of a cosmopolitan friendship.

After visiting a few of these wonderful countries, the United States grows smaller in one's estimation, and the only way we can keep it big is to be willing to broaden out as citizens. Many representatives of the medical profession of South America will visit the United States in the next few months and years. Let us look to our laurels! Remember that they have hospitals

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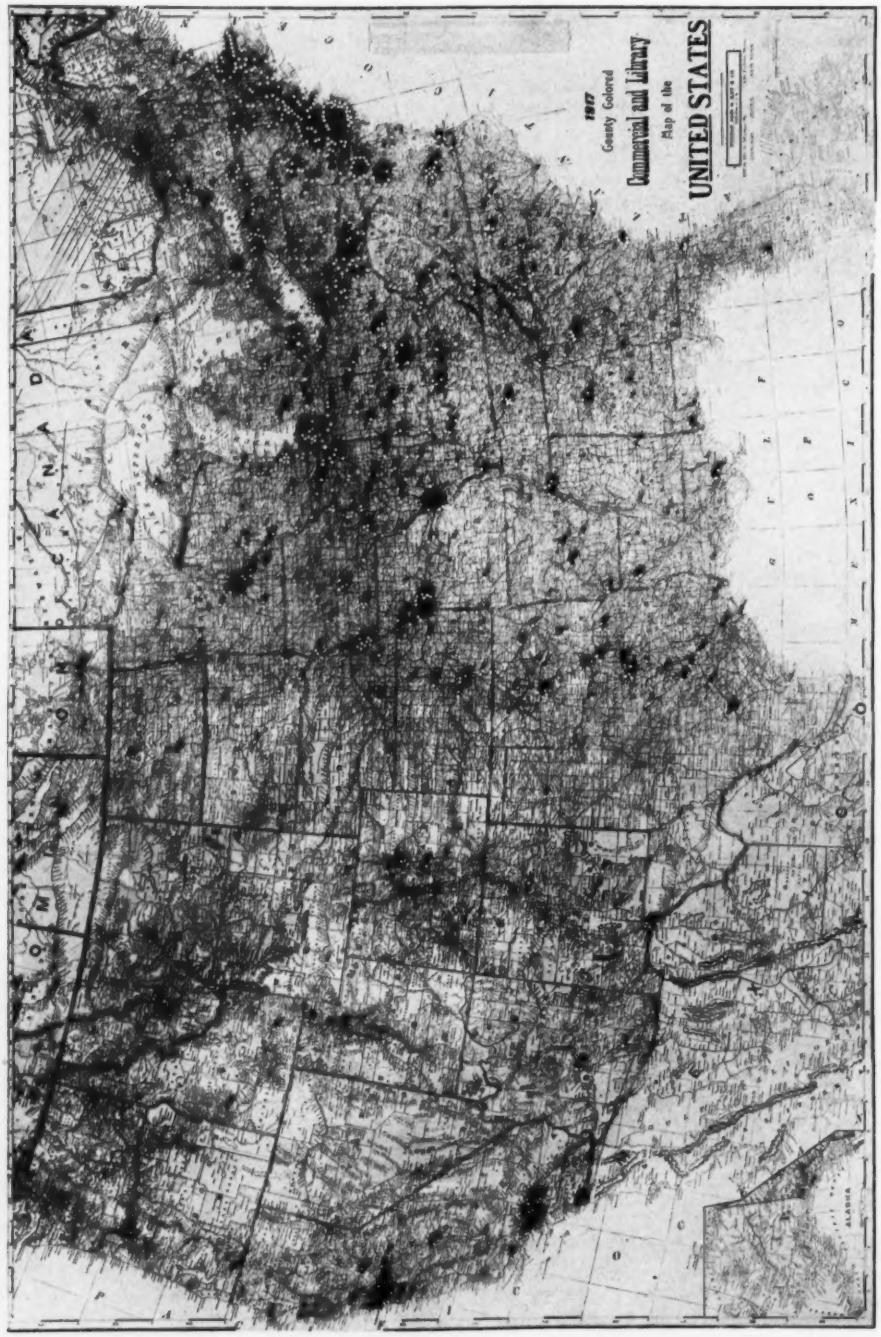
which are equal to our best, and most of them are much more attractive. Remember that each of their principal countries has a national medical university as thoroughly equipped as are our own, with world-trained faculties, and a seven-year curriculum as compared with our four- and five-year courses. Remember that the man you are entertaining has not been satisfied with the advantages afforded by his own country, but that he has also observed the best in France and in Germany. Remember that you are associating with a man from a country where a classical education is the pre-requisite of a gentleman. The United States now has the opportunity to enter into competition with the countries of the world as a medical-educational center. There is but one way to make good, and that is to utilize our great resources to the fullest extent and to do it with the realization that we are only one of the many nations which possess unusual resources. If it is possible, let us cultivate modesty, and the best way to do that, and certainly a pleasant way, is to visit the medical profession of South America.



Map showing 1667 general hospitals of the United States and Canada included in survey of American College of Surgeons. The black dots indicate 671 institutions with a capacity of 100 or more beds. The white dots indicate 996 institutions with a capacity of 50 to 100 beds.

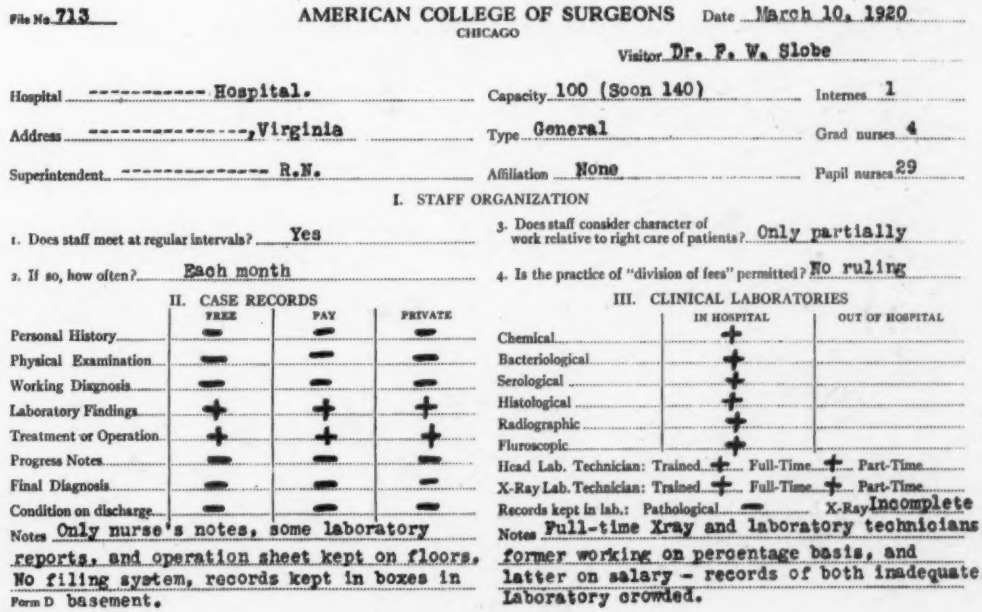
THE PROCESS OF HOSPITAL STANDARDIZATION

THE minimum standard of the College in its hospital program is now familiar to a majority of the physicians and surgeons of the continent and it is well known to practically every hospital superintendent. Further, doctors and superintendents know that the minimum standard is their own expression as to the first essentials in the right care of patients. The time of discussion has gone by and the time of action has arrived. Some details of this action, or of the process of standardization, may be of interest.

On the map appearing on the opposite page are 1667 black and white dots. These mark the general hospitals for the care of acute diseases in the United States and Canada. Each black dot represents a general hospital with a capacity of 100 or more beds, of which there are 671. Each white dot represents a hospital of from 50 to 100 beds, of which there are 996.

The program of the College for 1920 is, through its staff of visitors, to explain in detail to superintendents, staffs, and trustees of these hospitals what the minimum standard is, what the problems are which arise in connection with it, and what the practical solutions to these problems are as determined by experience among hospitals. Further, the visitors are to collect exact information as to the extent to which each hospital fulfills the standard. The visitor's record card as shown below illustrates the fashion in which this information is gathered. On the face of the card the visitor reports concerning staff meetings, case records, and laboratory service; on the reverse side of the card, concerning the number of deaths, autopsies, facilities for pathological work. General notes are also included.

At the present time there are seven visitors of the College—all men with medical education—at work in the field. One is now in Louisiana, one in South Carolina, one in New Jersey, another in Michigan, another in Ohio, still another in Oklahoma, and two in Canada. The number of field workers is to be increased. The work of the visitor is to be helpful and constructive. With this policy thoroughly understood, he starts on an itinerary planned some two months in advance. The hospitals are notified in advance of each visit. On visiting a hospital the man in the field mails a daily report to the central office. With



File No. 713

AMERICAN COLLEGE OF SURGEONS
CHICAGO

Date March 10, 1920

Visitor Dr. F. W. Slobe

Hospital ---------- Hospital. Capacity 100 (Soon 140) Interns 1

Address ----------, Virginia Type General Grad nurses 4

Superintendent ---------- R.N. Affiliation None Pupil nurses 29

I. STAFF ORGANIZATION

1. Does staff meet at regular intervals? Yes

2. If so, how often? Each month

3. Does staff consider character of work relative to right care of patients? Only partially

4. Is the practice of "division of fees" permitted? No ruling

II. CASE RECORDS

	FREE	PAY	PRIVATE
Personal History	−	−	−
Physical Examination	−	−	−
Working Diagnosis	−	−	−
Laboratory Findings	+	+	+
Treatment or Operation	+	+	+
Progress Notes	−	−	−
Final Diagnosis	−	−	−
Condition on discharge	−	−	−

Notes Only nurse's notes, some laboratory reports, and operation sheet kept on floors. No filing system, records kept in boxes in basement.

III. CLINICAL LABORATORIES

	IN HOSPITAL	OUT OF HOSPITAL
Chemical	+	
Bacteriological	+	
Serological	+	
Histological	+	
Radiographic	+	
Fluroscopic	+	

Head Lab. Technician: Trained + Full-Time + Part-Time

X-Ray Lab. Technician: Trained + Full-Time + Part-Time

Records kept in lab.: Pathological − X-Ray Incomplete

Notes Full-time Xray and laboratory technicians; former working on percentage basis, and latter on salary – records of both inadequate. Laboratory crowded.

Form D

this daily report are enclosed cards with the information gathered at each of the hospitals. At the end of each week the visitor also sends to the College a letter which covers in minute detail the results of his week's effort. He reports especially suggestions of value which he has received, and he gives any information which in his opinion will make for the betterment of the work.

Busy superintendents, busy doctors, and busy trustees are cordial in their co-operation. As one doctor put the matter: "It is wise that we lead now in a program for the better care of patients rather than to be forced later by the public to follow in such a program."

The following extract taken from the instructions issued to each hospital visitor tells its own story:

"The visitor is to collect facts and he is to collect facts only with the good will and approval of the respective hospitals. His mission is business. He is not a detective, an unbidden critic, nor a social caller. He is not to make comparisons of one institution with another. He is to be helpful and constructive. The success of his visit will depend much upon his sincerity. He must *believe* in his work. The visitor who is unwelcome has in all probability not wisely handled the situation."